RESEARCH BULLETIN 1031 DECEMBER 1969

Interrelationships of Shell and Breaking Egg Markets

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AGDEX 451/848 12-69-2.5M

Interrelationships of Shell and Breaking Egg Markets[1]

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INTRODUCTION

Some members of the egg industry have been concerned with the level and the amount of fluctuation in egg prices for many years. As a result, special efforts by the National Association of State Secretaries of Agriculture encouraged the U. S. Congress to appropriate funds for a research program on egg pricing. The broad objectives of this research program were to investigate possible improvements in establishing market quotations or base prices for eggs and to evaluate and test alternatives to the present system. Among these alternatives are committee and formula pricing.

Some of the specific areas to be researched under this program included: (1) an evaluation of the use of industry or quasi-public pricing committees for establishing egg price quotations, (2) an evaluation of the kinds and sources of information currently available to aid in the price determination process, (3) the development of methods to obtain additional information which would improve the price determination process, and (4) the development of an experimental framework for empirically testing committee and formula pricing.

OBJECTIVES

An examination of both the broad objectives and the specific areas to be researched suggests that the problem centers around the modification of the institutional framework of the egg pricing system. Modifications of the institutional structure and effective improvements of the market for eggs require an understanding of the market and of the interrelationships and interactions within the market.

The objectives of this study are to develop models describing the interrelationships between the shell and breaking egg markets and to provide the kinds of information relevant to a pricing committee. Specifically, the problems undertaken are: (1) to specify the structural relations which determine the allocation of egg production between shell and breaking use and which determine prices in a single month, (2) to obtain numerical values of quantities used and prices, and (3) to demonstrate the ability of the models to predict prices and quantities in any particular month.

PRODUCTION AND UTILIZATION

Trends in Production

Egg production in the United States increased 14 percent between 1960 and 1967. For the same period, egg production increased 64 percent in the South and 31 percent in the West but it declined 6 percent in the Northeast and 25 percent in the West North Central region (Table 1). Data on egg production by months for geographic regions and for the United States for the period 1960 to 1967 are presented in Appendix C.

These production changes have resulted in substantial shifts in the regional distribution of egg production. In 1960, the Northeast produced 34 percent of the eggs; the South, 27 percent; the West North Central region, 25 percent; and the West, 14 percent. By 1967, the South had become the major producing area and accounted for 39 percent of U. S. farm egg production. By comparision, the West North Central division accounted for 16 percent of U. S. egg production in 1967 (Table 2).

These shifts in production tended to stimulate egg breaking activity in the Northeast, South, and West. Especially noteworthy was the rapid increase in egg breaking plants in the South Atlantic states.[3] Another "growing development in the egg industry" (which appears to be associated with the changing regional pattern of egg production) "is the formation of large-scale specialized egg producing units, resembling factory production systems."[4]

Utilization

The major uses for eggs are for consumption in shell form as table eggs, for breaking for use in egg products, and for hatching. According to Rogers and Conley, about 80-85 percent of the eggs produced are marketed as shell eggs, 10-15 percent as egg products in frozen or solids form, and 6 percent as hatching eggs.[5] Between 1962 and 1967, total consump-

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[1]This study was partially financed with funds provided by Congress for egg pricing research and was done under cooperative agreement with the poultry group of the Marketing Economics Division, Economic Research Service, U. S. Dept. of Agriculture, Supplement No. 1-ME to Basic Memorandum of Agreement No. 12-17-01-7-220. It is part of a broad program of research of the U. S. Dept. of Agriculture and 13 cooperating states.

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[3]Koudele, Joe W. and E. C. Heinsohn. 1964. The Egg Products Industry of the United States. Kansas Agri. Exp. Sta., Bull. 466, p. 12.

[4]National Commission on Food Marketing. 1966. Organization and Competition in the Poultry and Egg Industries. Tech. Study No. 2, Washington, D. C.

[5]Rogers, George B. and Frank M. Conley. 1966. Marketing Poultry and Eggs. In Agricultural Markets in Change, Agri. Econ. Report 95, Econ Res. Serv., U. S. Dept. of Agriculture, p. 330.

TABLE 1.—Index of Average Daily Egg Production by Regions, 1960-1967.

Region	Index (1960 = 100)							
	1960	1961	1962	1963	1964	1965	1966	1967
West North Central*	100.0	98.0	93.8	84.2	82.1	78.5	74.0	75.2
South†	100.0	107.5	115.4	124.9	134.9	140.6	149.7	163.6
West‡	100.0	105.5	110.9	112.7	117.5	118.8	122.2	131.2
Northeast**	100.0	97.0	96.8	95.0	94.5	94.3	92.4	94.3
United States	100.0	101.3	103.1	103.0	105.8	106.6	107.8	113.8

*Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

†Maryland, Delaware, Virginia, West Virginia, North Carolina, Georgia, South Carolina, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas.

‡Montana, Wyoming, Idaho, Colorado, Nevada, Utah, Washington, Oregon, California, New Mexico, and Arizona.

**Ohio, Indiana, Illinois, Michigan. Wisconsin, Massachusetts, Connecticut, Rhode Island, Vermont, New York, New Jersey, Pennsylvania, New Hampshire, and Maine.

Source: Appendix C.

TABLE 2.—Average Daily Egg Production: Percentage of United States Total, by Regions, 1960-1967.

Region	Percentage of United States Production							
	1960	1961	1962	1963	1964	1965	1966	1967
West North Central	24.6	23.8	22.4	20.1	19.1	18.1	16.9	16.3
South	27.4	29.1	30.7	33.2	35.0	36.2	38.1	39.4
West	14.1	14.6	15.1	15.4	15.6	15.7	15.9	16.2
Northeast	33.9	32.5	31.8	31.3	30.3	30.0	29.1	28.1
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Appendix C.

tion of eggs in the shell and solids form and the number of eggs hatched showed upward trends. The number of eggs used in the frozen form, however, remained fairly stable (Fig. 1).

Regional Relationships Between End Uses

The nature of the relationship between uses for eggs tended to vary among producing regions. Consumption in shell form and breaking for use in egg products appear to be competing uses for the eggs produced in the West North Central region. Consumption in shell form and breaking for use in egg products appear generally to be supplementary market outlets for eggs produced in the Western, Southern, and Northeastern regions.

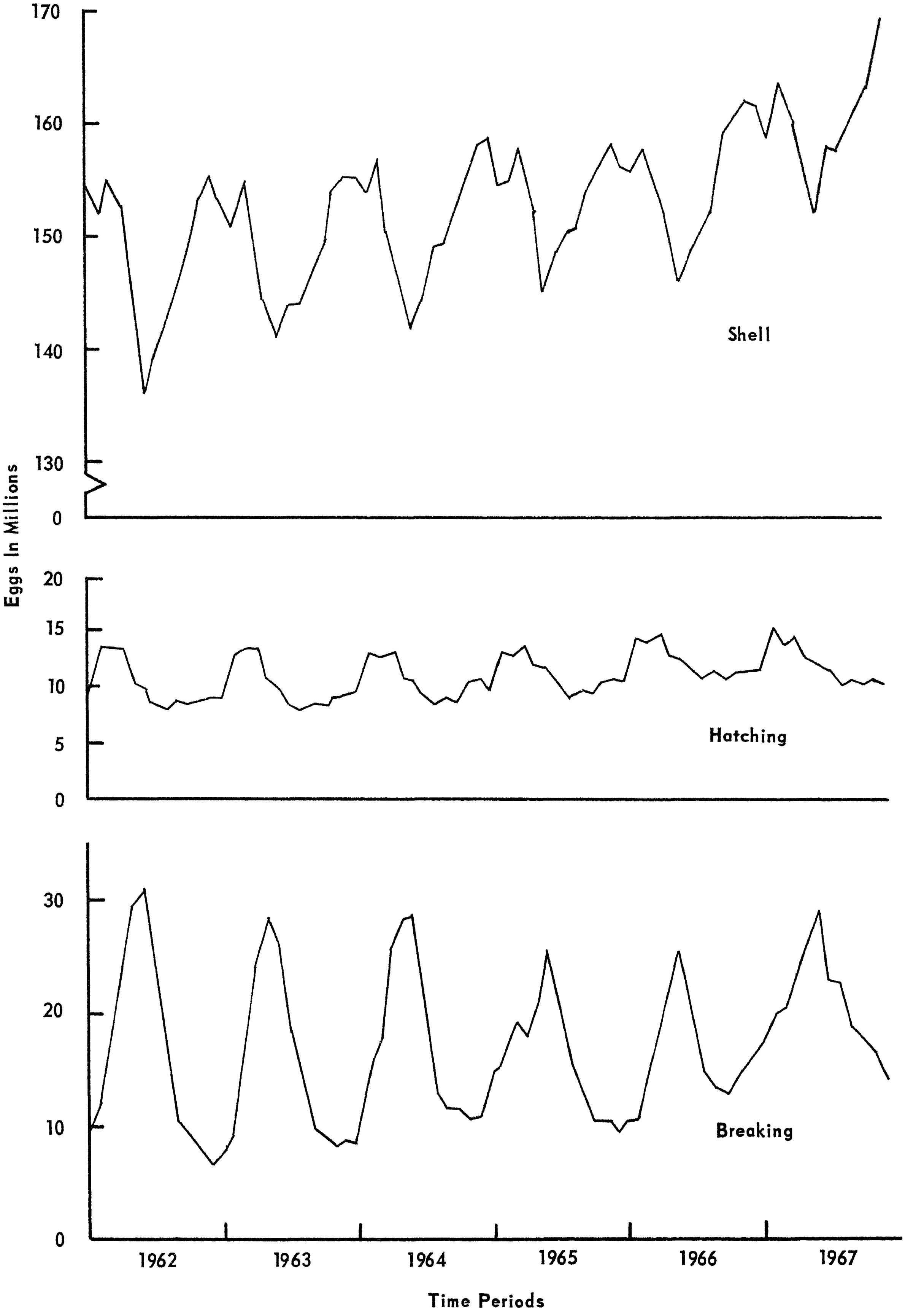
Rogers and Conley wrote: "The Midwest is still the major egg breaking and drying area. There is a basic difference between commercial breaking operations in the Midwest and in other regions. In the Midwest, the majority of plants are not connected with shell egg operations and are therefore competing buyers. This is a situation of long standing which continues to be disrupting to firms that wish to develop year-round outlets for quality eggs. To get supplies during the heavy breaking season, egg breakers frequently bid producers away from shell egg plants, thereby upsetting quality programs. While there are breaking operations in the South, the newer breakers have tended to appear only as a surplus has developed. This tends to be a support for shell egg prices rather than a seasonally disruptive force."[6]

The implication of the preceding statement is that differences in the relationship between uses for the eggs produced in the different production regions appear to be in the behavior of commercial egg breaking firms in each region. It should be pointed out, however, that commercial egg breakers are not confined to, nor have they restricted themselves to, procuring eggs within the region in which they are located.

This study was limited to an analysis and examination of the relationships between shell and breaking eggs on a national rather than on a regional level. The decision to restrict the analysis to the national level was made because of the unavailability of relevant data at the regional level. In effect, national

[6]Rogers, George B. and Frank M. Conley, **op cit.**, pp. 336-37.

FIG. 1.—Trends in Egg Utilization, 1962-1967.



aggregates must be used to attack a problem which has a strong regional orientation. The observation period covered in the study was 1962-1967. A longer period could not be used because some essential data were not available for years prior to 1962.

ECONOMETRIC MODELS

The market for eggs is much more complex than the five-equation system developed in this study. A comprehensive model for the egg market would recognize, among others, the several end uses for eggs, the different levels of marketing as eggs move from producer to consumer, and the existence of major production areas.

The models were restricted to the wholesale level of marketing. Typical firms operating at the wholesale level are breakers, retail buyers, producer-distributors, assembler-distributors, assembler-shippers, and wholesale-distributors. Producer-distributors and assembler-distributors "are replacing two types of firms—assembler-shippers, who operated in producing areas, and wholesale-distributors, who distributed eggs within large cities."[7]

Structural relations describing the utilization and price of hatching eggs have been excluded from the models. Accordingly, the models deal with eggs for consumption in shell form and for breaking for use in egg products.[8] The models include a supply and a demand equation for each use. They include also a price relation equation relating farm price in the West North Central region with the prices generated for each end use, since the West North Central states are still the major egg breaking and drying area.

MODEL I

Demand for Shell Eggs

On the basis of classical demand theory, the consumption-demand schedule or the quantity demanded of a particular commodity at retail is a function of its price, the prices of other commodities, and income. The demand for shell eggs at the wholesale level of marketing is not synonymous with the consumption-demand schedule for shell eggs.

The demand for shell eggs at the wholesale level of marketing may be regarded as a demand schedule for eggs to hold for resale. It is affected by opinions concerning the magnitude of existing supplies and is related to the consumption-demand schedule for shell eggs because it is based on expectations concerning the consumption-demand of shell eggs. Accordingly, the demand for shell eggs at the wholesale level of marketing is assumed to be a function of the price of eggs in the current period, its price in the preceding period, consumer income, prices of other foods in general, expectations concerning the magnitude of existing supplies, and expectations concerning consumption-demand.

Consumer income and the general level of food prices were so highly correlated with each other during the observation period that it was difficult to measure their separate effects on the demand for shell eggs. For this reason, the index of wholesale food prices was inserted in the relation to represent the composite effects of consumer income and the general level of food prices.

Expectations concerning the magnitude of existing supplies of eggs were represented in the relation by the number of layers in U. S. laying flocks over 9 months old and expectations concerning consumption demand by the change in the movement of eggs into retail channels for the preceding month over the same month a year ago.

The exact demand relation for shell eggs was written:

$$Y_{1t} = f_1 (Y_{3t}, Z_{1t}, Z_{3t}, Z_{4t}, Z_{9t}) \qquad (1)$$

where Y_1 represents shell egg utilization, Y_3 the price of shell eggs, Z_1 the index of wholesale food prices representing the composite effect of consumer income and the general level of food prices, Z_3 expectations concerning consumer demand represented by the percentage change in the movement of eggs into retail channels for the preceding month over the same month a year ago, Z_4 the value of Y_3 lagged 1 month, and Z_9 expectations concerning existing supplies of eggs represented by the number of layers in U. S. laying flocks over 9 months old. The Y's (utilization and prices of shell eggs) are assumed to be determined within the system in any particular month. The Z's are controlled by influences outside of the system.

A change in the quantity of shell eggs used is assumed to be negatively related to a change in the price of shell eggs. In other words, the partial derivative of Y_1 with respect to Y_3 is negative:

$$\frac{\delta Y_{1t}}{\delta Y_{3t}} < 0 \qquad (2)$$

A change in the quantity of shell eggs used is assumed: (1) to be positively related to a change in the general level of prices and income, (2) to be positively or negatively related to buyers' expectations about consumption-demand, (3) to be positively or negatively related to a change in the price of eggs lagged 1 month, and (4) to be positively or negatively related to expectations concerning the magnitude

[7]National Commission on Food Marketing, **op. cit.**

[8]Eggs consumed in shell form are henceforth referred to as shell eggs while eggs broken for use in egg products are referred to as breaking eggs.

of existing supplies. As a consequence, the following relations are expected:

$$\frac{\delta Y_{1t}}{\delta Z_{1t}} > 0 \tag{3}$$

$$\frac{\delta Y_{1t}}{\delta Z_{3t}} \gtreqless 0 \tag{4}$$

$$\frac{\delta Y_{1t}}{\delta Z_{4t}} \gtreqless 0 \tag{5}$$

$$\frac{\delta Y_{1t}}{\delta Z_{9t}} \gtreqless 0 \tag{6}$$

Supply of Shell Eggs

The quantity of eggs which producer-distributors, assembler-distributors, and assembler-shippers are willing to sell as shell eggs in a particular month depends upon the current price of shell eggs, the current price of breaking eggs, and the number of eggs produced.

Location of production may have an effect on supply because of the different relationships between uses of eggs in the different production regions. As a result of this factor and because a relatively high proportion of the eggs produced in the West North Central region are processed as breaking eggs in the region, production was divided into West North Central production and "other states" production. Egg production for periods as short as 1 month is assumed to be a predetermined variable. It is assumed to be determined outside the system. Shell egg utilization and the prices of shell and breaking eggs are assumed to be jointly determined within the system.

The exact supply relation for shell eggs was written:

$$Y_{1t} = f_2\,(Y_{3t}, Y_{4t}, Z_{6t}, Z_{7t}) \tag{7}$$

where Y_4 represents the price of breaking eggs, Z_6 West North Central farm egg production, and Z_7 "other states" farm egg production. It was assumed that Y_{1t}: (1) was positively related to Y_{3t}, (2) was negatively related to Y_{4t}, (3) was positively related to Z_{6t}, and (4) was positively related to Z_{7t}. Therefore, the following relations were expected:

$$\frac{\delta Y_{1t}}{\delta Y_{3t}} > 0 \tag{8}$$

$$\frac{\delta Y_{1t}}{\delta Y_{4t}} < 0 \tag{9}$$

$$\frac{\delta Y_{1t}}{\delta Z_{6t}} > 0 \tag{10}$$

$$\frac{\delta Y_{1t}}{\delta Z_{7t}} > 0 \tag{11}$$

Demand for Breaking Eggs

The demand for breaking eggs is related to: (1) the price of breaking eggs in the current period; (2) the wholesale price index representing the composite effects of consumer income and the general level of food prices; (3) expectations concerning existing supplies of eggs; (4) the price of shell eggs in the preceding period; (5) the prices at which egg products, particularly frozen or dried whole eggs, have been sold during the previous month; and (6) storage stocks of shell and frozen eggs.

Expectations concerning existing supplies have been represented by the number of pullets hatched 6 to 21 months ago.[9] Storage stocks of shell and frozen eggs were omitted from the relation describing the demand for breaking eggs because of: (1) its high degree of correlation with the price of shell eggs lagged 1 month, thus making it impossible to distinguish their separate effects on breaking egg use; (2) the tendency for the production of egg solids to come mainly from fresh shell eggs;[10] and (3) the down trend in storage stocks as a result of the changing seasonal and regional patterns of egg production. Utilization and prices of breaking eggs are assumed to be jointly determined within the system. The other variables listed are assumed to be predetermined.

As a consequence, the exact demand relation for breaking eggs was written:

$$Y_{2t} = f_3\,(Y_{4t}, Z_{1t}, Z_{2t}, Z_{4t}, Z_{5t}) \tag{12}$$

where Y_2 represents breaking egg utilization, Z_2 the number of pullets hatched 6-21 months ago, and Z_5 the price of egg products lagged 1 month. A change in Y_2 is assumed to be: (1) negatively related to a change in Y_4, (2) positively related to a change in Z_1, (3) positively or negatively related to a change in Z_2, (4) positively or negatively related to a change in Z_4, and (5) positively related to a change in Z_5. These assumptions are summarized as follows:

$$\frac{\delta Y_{2t}}{\delta Y_{4t}} < 0 \tag{13}$$

[9]Expectations concerning existing supplies have been represented by the number of layers in U. S. laying flocks over 9 months old in the shell egg relation and by the number of pullets hatched 6 to 21 months ago in the breaking egg relation. The reason for this is that in the shell egg relation the critical decision-making factor is the supply of large eggs, while in the breaking egg relation it is the supply of all eggs.

[10]See Koudele and Heinsohn, **op cit.**, pp. 28-30.

$$\frac{\delta Y_{2t}}{\delta Z_{1t}} > 0 \qquad (14)$$

$$\frac{\delta Y_{2t}}{\delta Z_{2t}} \gtreqless \qquad (15)$$

$$\frac{\delta Y_{2t}}{\delta Z_{4t}} \gtreqless 0 \qquad (16)$$

$$\frac{\delta Y_{2t}}{\delta Z_{5t}} > 0 \qquad (17)$$

Supply of Breaking Eggs

The quantity of eggs which distributors and shippers are willing to sell for breaking purposes in a particular month depends upon the price of breaking eggs, the price of shell eggs, egg production in the West North Central region, and egg production in "other states". The exact supply relation for breaking eggs is:

$$Y_{2t} = f_4 \, (Y_{3t}, Y_{4t}, Z_{6t}, Z_{7t}) \qquad (18)$$

As indicated before, prices and utilization are assumed to be determined within the system and production to be determined outside the system. The assumptions concerning the partial derivatives are summarized:

$$\frac{\delta Y_{2t}}{\delta Y_{3t}} < 0 \qquad (19)$$

$$\frac{\delta Y_{2t}}{\delta Y_{4t}} > 0 \qquad (20)$$

$$\frac{\delta Y_{2t}}{\delta Z_{6t}} > 0 \qquad (21)$$

$$\frac{\delta Y_{2t}}{\delta Z_{7t}} > 0 \qquad (22)$$

Price Level Relation—West North Central Region

The farm price of eggs in the West North Central region depends on the price of shell eggs, the price of breaking eggs, marketing costs represented by wage rates in food and kindred industries, and egg production in the West North Central region.

The exact price level relation was written:

$$Y_{5t} = f_5 \, (Y_{3t}, Y_{4t}, Z_{6t}, Z_{8t}) \qquad (23)$$

where Z_8 represents the average wage rate in establishments manufacturing food and kindred products. Prices are assumed to be jointly determined within the system but marketing costs, represented by average wage rates in food and kindred manufacturing establishments, and egg production are assumed to be predetermined. The assumptions about the partial derivatives are summarized as follows:

$$\frac{\delta Y_{5t}}{\delta Y_{3t}} > 0 \qquad (24)$$

$$\frac{\delta Y_{5t}}{\delta Y_{4t}} > 0 \qquad (25)$$

$$\frac{\delta Y_{5t}}{\delta Z_{6t}} < 0 \qquad (26)$$

$$\frac{\delta Y_{5t}}{\delta Z_{8t}} < 0 \qquad (27)$$

Variables

The variables which enter into the exact structural model are listed below, identified symbolically, and classified into endogenous and predetermined categories.[11]

The following variables are assumed to be endogenous for this analysis:

Y_1 = Average daily shell egg utilization, millions.

Y_2 = Average daily breaking egg utilization, millions.

Y_3 = Average New York wholesale selling price of shell eggs, cents per dozen.

Y_4 = Average prices paid for breaking stock, Chicago standards and farm run, dollars per case.

Y_5 = Average prices paid at farm, Iowa, cents per dozen.

The following variables are assumed to be predetermined for this analysis:

Z_1 = Index of wholesale prices of food.

Z_2 = Number of pullets hatched 6 to 21 months ago, millions.

Z_3 = Percentage change in the movement of eggs into retail channels for the previous month over the same month a year ago.

Z_4 = Y_3 lagged 1 month.

Z_5 = Lagged price for frozen whole eggs, cents per pound.

Z_6 = Average daily egg production, West North Central states, millions.

Z_7 = Average daily egg production, other states, millions.

[11]The endogenous variables are those variables whose values are considered jointly determined by the interaction among the variables in the relations of the model. Predetermined variables, which include lagged endogenous variables, are those variables in the model which are considered to be determined outside the operation of the model.

Demand for shell	$Y_{1t} + \beta_{13}Y_{3t} + \gamma_{11}Z_{1t} + \gamma_{13}Z_{3t} + \gamma_{14}Z_{4t} + \gamma_{19}Z_{9t} + \alpha_1 = U_1$	(28)
Supply of shell	$Y_{1t} + \beta_{23}Y_{3t} + \beta_{24}Y_{4t} + \gamma_{26}Z_{6t} + \gamma_{27}Z_{7t} + \alpha_2 = U_2$	(29)
Demand for breaking	$Y_{2t} + \beta_{34}Y_{4t} + \beta_{31}Z_{1t} + \gamma_{32}Z_{2t} + \gamma_{34}Z_{4t} + \gamma_{35}Z_{5t} + \alpha_3 = U_3$	(30)
Supply of breaking	$Y_{2t} + \beta_{43}Y_{3t} + \beta_{44}Y_{4t} + \gamma_{46}Z_{6t} + \gamma_{47}Z_{7t} + \alpha_4 = U_4$	(31)
Price level equation	$\beta_{53}Y_{3t} + \beta_{54}Y_{4t} + Y_{5t} + \gamma_{56}Z_{6t} + \gamma_{58}Z_{8t} + \alpha_5 = U_5$	(32)

Z_8 = Average hourly wage rate in establishments manufacturing food and kindred products, dollars.

Z_9 = Number of layers in U. S. laying flocks over 9 months, millions.

The variables representing egg utilization, Y_1 and Y_2, are national aggregates, while the variables representing production, Z_6 and Z_7, are regional aggregates. The price variables reflect prices at specific points—New York, Chicago, and Iowa. Point prices were used because the practice of using quotations as base prices is well established in the egg industry.

Stochastic Assumptions

The relations in the model were assumed to hold exactly. However, these relations do not include all relevant variables which influence the interaction process but only those considered more important. The net effect of the excluded variables may be explicitly recognized in each of the five relations of the model by a disturbance term u. The assumption of exact relations is relaxed and is replaced by one of stochastic relations by including a disturbance term u in each of the five structural relations of the model.

The disturbances, u's, are assumed to be random variables with zero means and finite variances and covariances in each observation period t. The joint distribution of (u_{1t}, u_{2t}, u_{3t}, u_{4t}, u_{5t}) is assumed to be the same for every t for T periods. Within each structural relation, the disturbance term is assumed to be independent of every predetermined variable in the relation. Within each relation, the u's in every period are assumed to be independent of those in every other period.

Structural Equations

The model is linear and contains the five equations shown at the top of this page.

The 5 equations in the model of the egg industry have been summarized in matrix notation by the statement:

$$\beta Y'_t + \Gamma Z'_t + A'_t = U'_t \qquad (33)$$

$$\beta = \begin{bmatrix} \beta_{11} & \beta_{12} & \bullet & \bullet & \beta_{15} \\ \beta_{21} & \beta_{22} & \bullet & \bullet & \beta_{25} \\ \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet \\ \beta_{51} & \beta_{52} & \bullet & \bullet & \beta_{55} \end{bmatrix}$$

$$Y'_t = \begin{bmatrix} Y_{1t} \\ Y_{2t} \\ Y_{3t} \\ Y_{4t} \\ Y_{5t} \end{bmatrix} \qquad Z'_t = \begin{bmatrix} Z_{1t} \\ \bullet \\ \bullet \\ \bullet \\ Z_{9t} \end{bmatrix}$$

$$\Gamma = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \bullet & \bullet & \gamma_{19} \\ \gamma_{21} & \gamma_{22} & \bullet & \bullet & \gamma_{29} \\ \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet \\ \gamma_{51} & \gamma_{52} & \bullet & \bullet & \gamma_{59} \end{bmatrix}$$

$$A'_t = \begin{bmatrix} \alpha_{1t} \\ \alpha_{2t} \\ \alpha_{3t} \\ \alpha_{4t} \\ \alpha_{5t} \end{bmatrix} \qquad U'_t = \begin{bmatrix} U_{1t} \\ U_{2t} \\ U_{3t} \\ U_{4t} \\ U_{5t} \end{bmatrix}$$

Data Adjustments

Some of the erratic influences were eliminated from the variables Y_1, Y_2, Z_6, and Z_7 by adjusting the monthly values of these variables for differences in the number of days in the months of the year.

Breaking egg utilization in any given month was obtained by converting liquid egg production in that month by an average monthly liquid yield per case for eight plants for the 1966-1967 period.[12] Breaking egg utilization, so derived, includes the shell egg equivalent of USDA purchases of dried eggs. To obtain shell egg utilization, the derived breaking egg utilization and eggs used for hatching were subtracted from eggs produced on farms.

Average edible liquid yields per case, in pounds, from eight plants for 1966-1967 for each month of the year, were:

Jan.	Feb.	March	April	May	June
38.4	39.1	39.8	39.7	39.6	38.9
July	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
37.5	36.8	36.8	36.8	37.0	37.5

USDA uses a fixed liquid yield factor of 39.5 lb. per case in converting liquid egg production to eggs broken commercially.

If eggs used for hatching are assumed to be measured accurately, then a constant liquid yield per case of 39.5 lb. tends to underestimate the number of eggs broken commercially and overestimate the utilization of shell eggs in those months in which the constant liquid yield factor of 39.5 lb. exceeded the average monthly liquid yield of eight plants. Except for March, April, and May, the average monthly liquid yield per case was lower than the USDA conversion factor of 39.5 lb.

MODEL II

With observation periods shorter than a year, factors peculiar to a given month as well as intra-seasonal factors may influence egg utilization and prices. Model II incorporates the effects of seasonal variation in egg production, utilization, and prices.

Seasonal Variation in Production

The seasonal pattern of egg production in the United States, the West North Central region, and "other states" has been changing. For the period under study, the ratios of monthly egg production to the 12-month moving averages of egg production have been trending upwards in July to January for "other states" and the United States. In the West North Central region, the upward trends have been in the ratios for July to October (Figures 2, 3, and 4).

The linearly changing index of seasonal variation in egg production by regions and the annual rate of change in the monthly indices are listed in Appendix B, Tables III, IV, and V. These tables show that in all three regions, egg production in the month of September in relation to production in the other months of the year has been increasing most rapidly. In the West North Central region and in the United States, egg production in March has shown the largest relative rate of decrease; in "other states", April egg production exhibited the largest relative rate of decline.

Seasonal Variation in Utilization

Breaking egg utilization was below the annual average in August to January but above the annual average in March to July (Figure 5). Seasonal variation in breaking egg use has been rather pronounced. The most rapid rate of increase in the index of linearly changing seasonal variation in breaking egg utilization was in February; the most rapid rate of decrease was in March. For the period under study, the February index rose at the rate of 10.2 percentage points per year but the March index declined at the rate of 14.9 percentage points per year (Appendix B, Table VI).

In contrast to the changing pattern in breaking egg use, the change in the pattern of seasonal variation in shell utilization has been quite moderate. The maximum rate of decline in the linearly changing index of seasonal variation in shell egg use was .48 percentage point per year in the month of March. The maximum rate of increase in this index was .51 percentage point per year in May (Appendix B, Table VII).

The relative stability in the seasonal pattern of shell egg use suggests that any shocks caused by seasonal changes in egg production tended to be absorbed in part by changes in breaking egg use. Figure 6 shows that utilization of shell eggs was generally below average in May, June, July, August, and September but generally above average in November, December, January, February, and March.

Seasonal Variation in Egg Prices

The seasonal pattern of shell egg prices in January and July is of special interest. For the period under study, shell egg prices in January moved from above average for the year to below average but moved in July from below average for the year to above average (Figure 7). In addition, the ratios of monthly prices to the 12-month moving average of shell egg prices showed considerable variation in several months. As an example, the range in the ratios for April, for the period studied, was 20 percentage

[12]The assistance of Leonard Voss, agricultural economist, University of Missouri, on leave with the USDA to serve as coordinator of the pricing study, in obtaining plant yield data as well as the cooperation of industry members is greatly appreciated.

FIG. 2.—Seasonal Variation in United States Egg Production, July-June, 1961-1967.

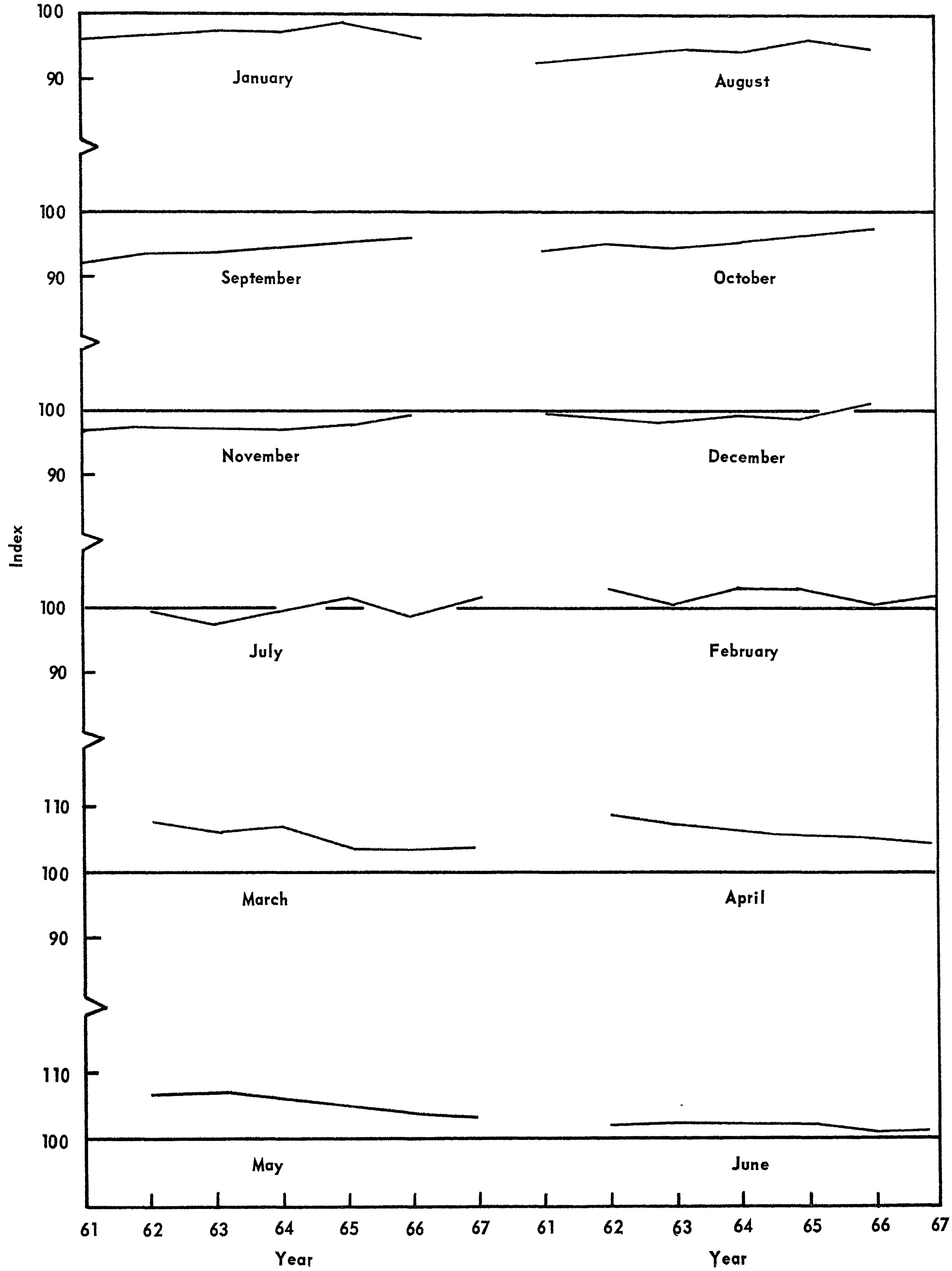


FIG 3.—Seasonal Variation in West-North Central Egg Production, July-June, 1961-1967.

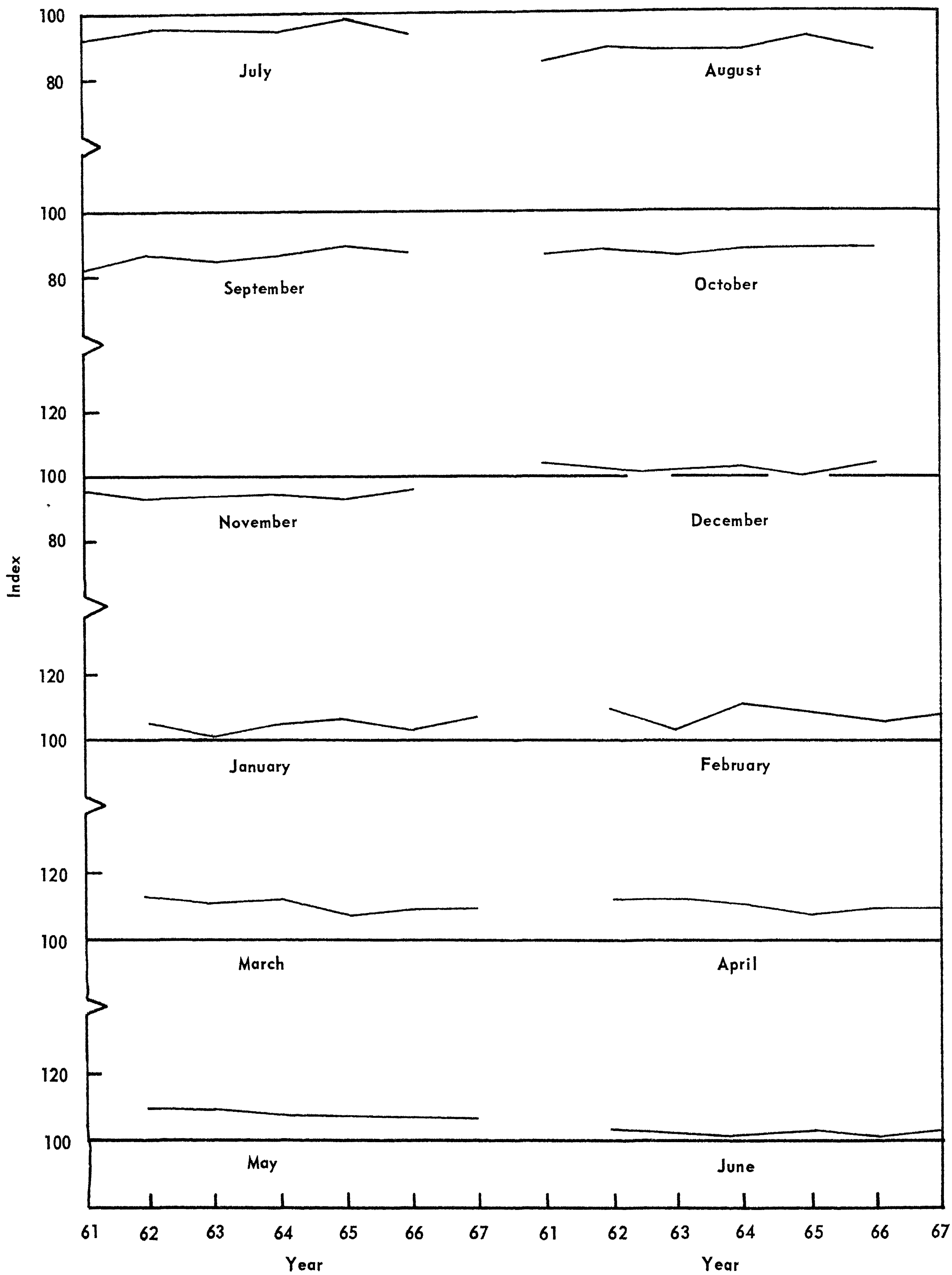


FIG. 4.—Seasonal Variation in Egg Production in States Other Than West-North Central, July-June, 1961-1967.

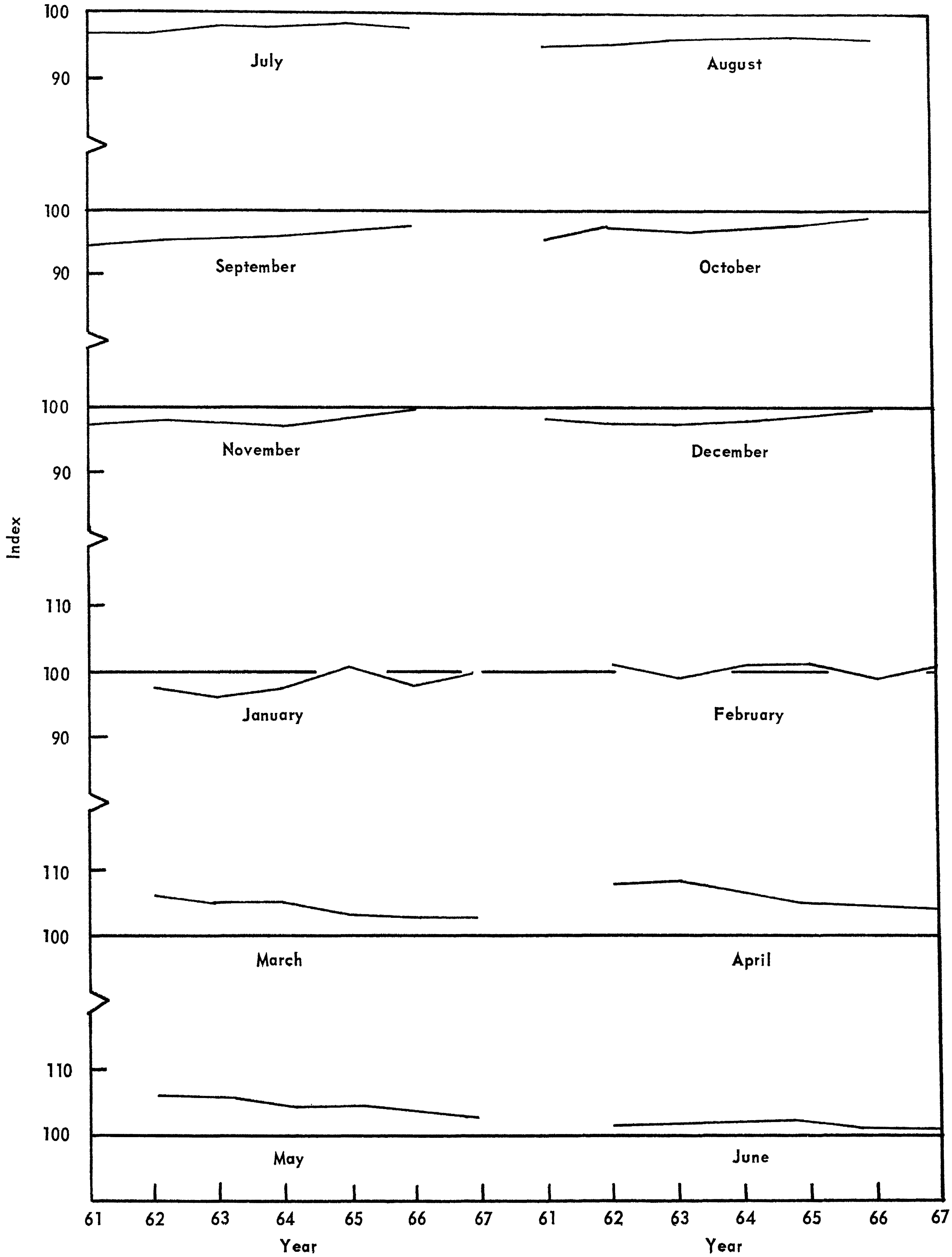


FIG. 5.—Seasonal Variation in Breaking Egg Utilization, July-June, 1961-1967.

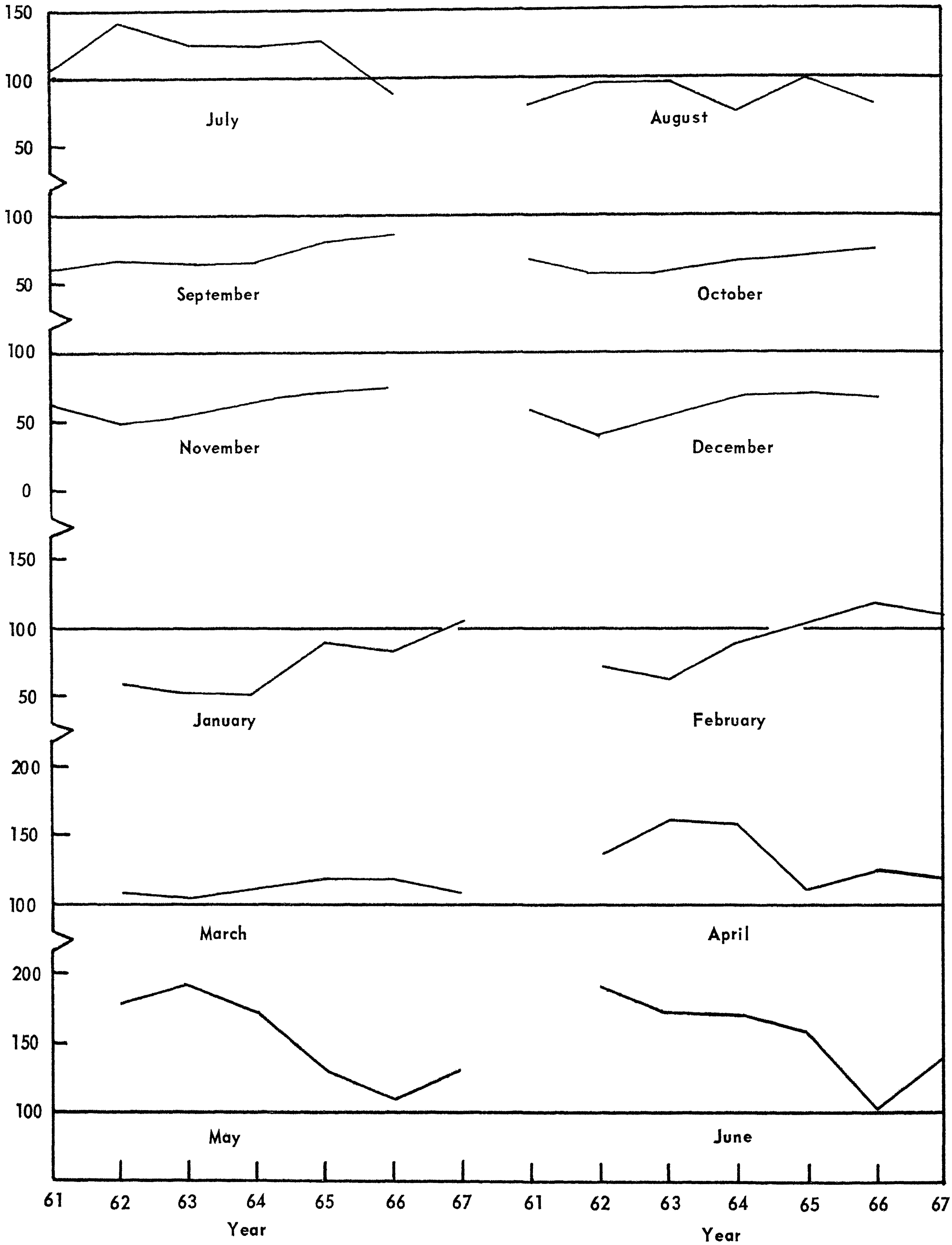


FIG. 6.—Seasonal Variation in Shell Egg Utilization, July-June, 1961-1967.

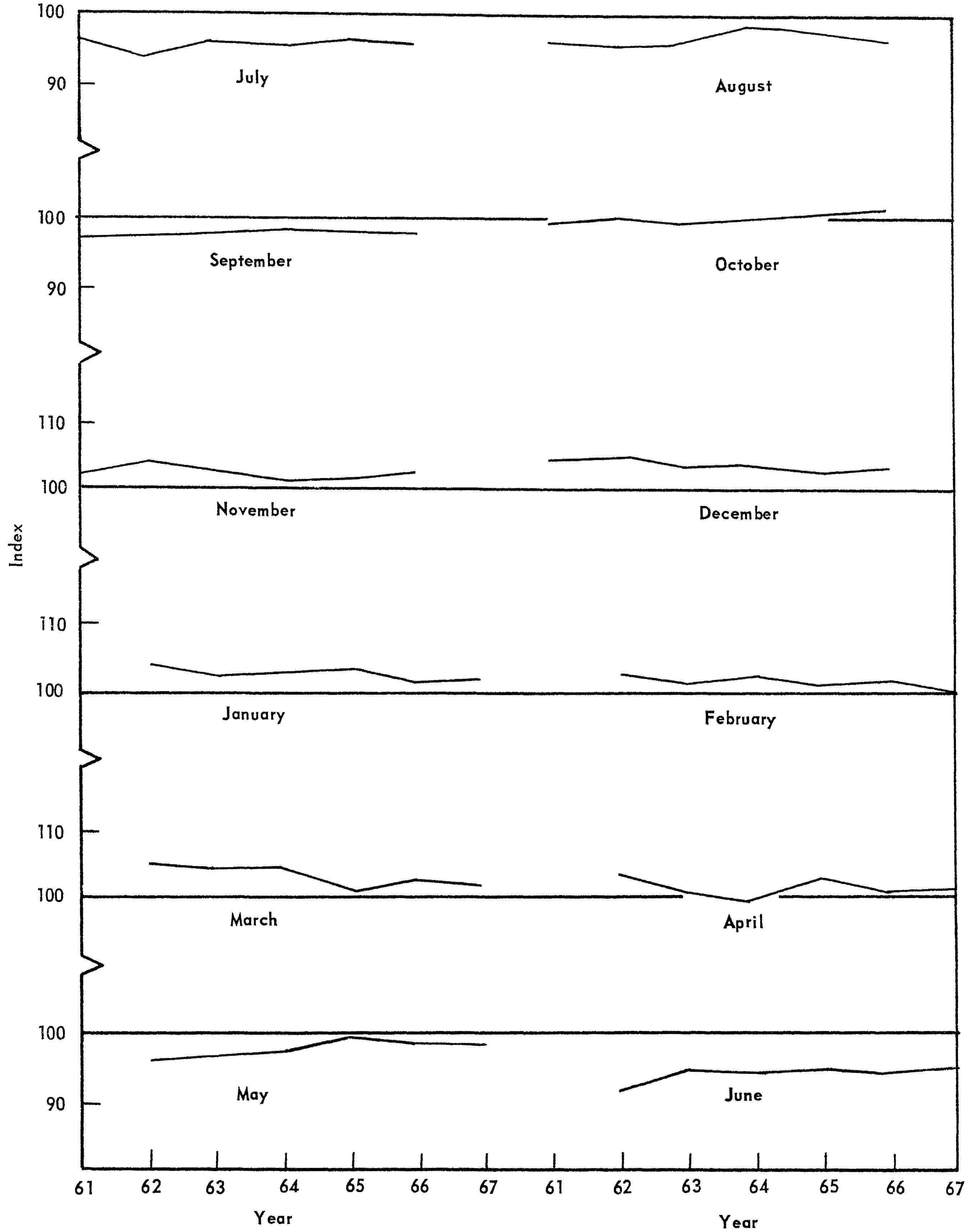


FIG. 7.—Seasonal Variation in Shell Egg Prices, New York, Extra Fancy, Large, White, July-June, 1961-1967.

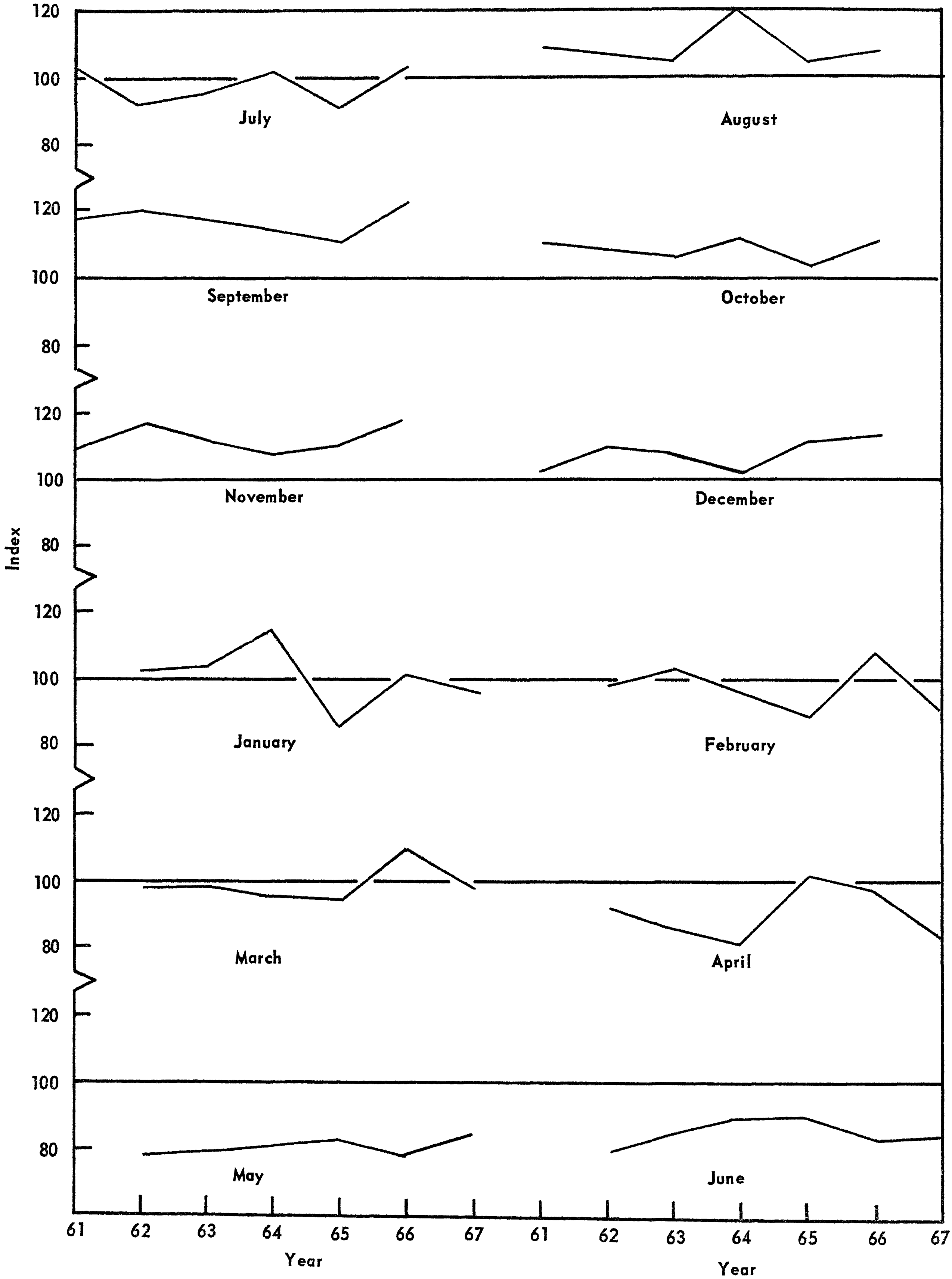


FIG. 8.—Seasonal Variation in Breaking Egg Prices, Chicago Standards and Farm Run Prices, July-June, 1961-1967.

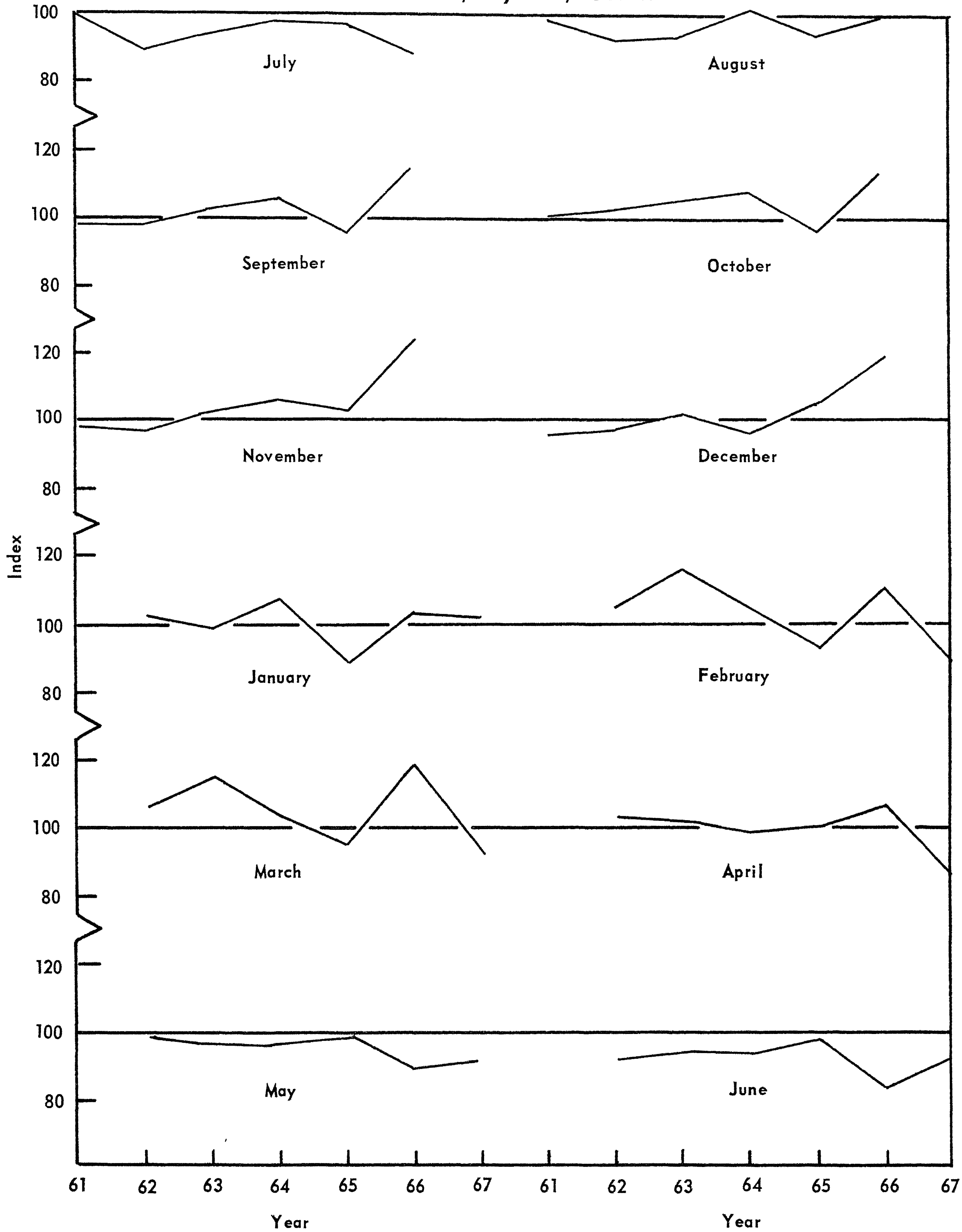
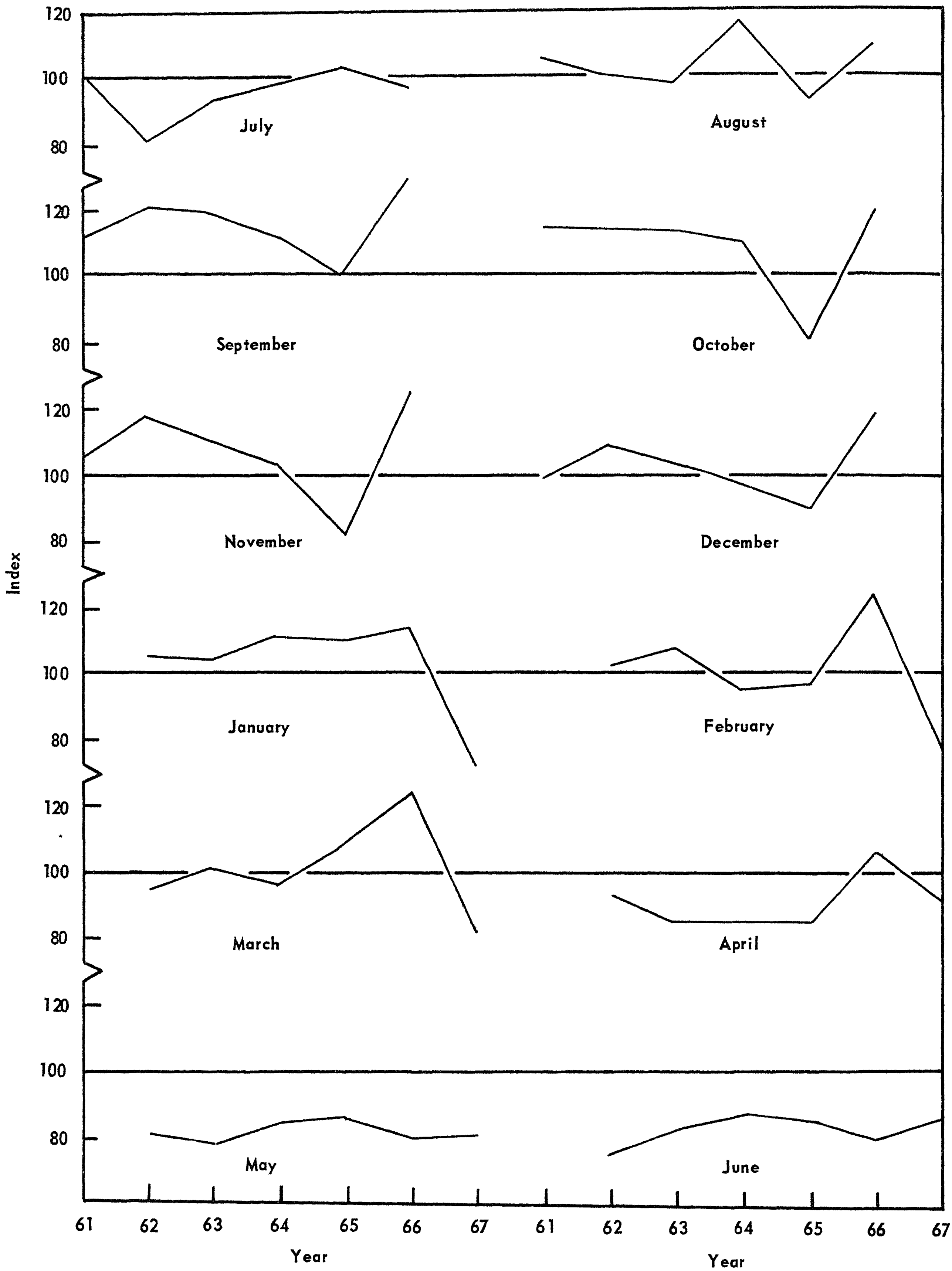


FIG. 9.—Seasonal Variation in Iowa, "Other Farm" Prices, July-June, 1961-1967.



points. The December index of seasonal variation in shell egg prices exhibited the largest annual rate of increase. The January index showed the largest annual rate of decrease (Appendix B, Table VIII).

In contrast to the pattern of change in the index of seasonal variation in shell egg prices, the seasonal pattern in breaking egg prices has undergone considerable change. The November index of linearly changing seasonal variation in breaking egg prices exhibited the largest annual rate of increase and the February index the largest annual rate of decrease (Appendix B, Table IX).

The ratios of monthly breaking egg prices to the 12-month moving average of breaking egg prices tended to vary widely. There was a downward trend in these ratios in January to April and an upward trend in September to December. Breaking egg prices were generally below the annual average in May, June, July, and August. For the period studied, December breaking egg prices moved from below to above average, while January breaking egg prices moved from above to below the annual average (Figure 8).

The sharp decline in the ratios of monthly Iowa farm prices to the 12-month moving average of Iowa farm prices for August to December 1965 parallels, although more pronounced, the decline in the breaking egg monthly price ratios to the 12-month moving average of breaking egg prices for the same months and year. The Iowa farm price ratios to moving average, with the exception of May and June, showed extremely wide variation (Figure 9). The most significant change in the index of seasonal variation in Iowa farm prices was the decline in egg prices in January relative to prices in other months. The January index declined at an annual rate of 3.7 percentage points (Appendix B, Table X).

The manner in which seasonal factors can be incorporated in the model depends on the assumptions made about the effects of the seasonal influences on the structural relations.

Structural relations may be considered to shift between different seasons. With an assumption of shifts in the structural relations, the seasonal influences can be explicitly measured by the use of dummy variables.

Alternatively, seasonal influences may be considered to induce changes in the structural relations themselves, as well as shifts between seasons. When seasonal influences are assumed to induce changes in the structural relations themselves as well as shifts in the relations between seasons, the seasonal influences may be analyzed by obtaining structural estimates for each month or for each quarter.

In Model II, the assumption is that the structural relations shift between different seasons. Model II, therefore, differs from Model I by the inclusion of dummy variables Z_{10}, Z_{11}, and Z_{12} in each of the structural relations, where:

$$Z_{10} \text{ takes on the value } \begin{cases} 1 & \text{2nd quarter} \\ 0 & \text{not 2nd quarter} \end{cases}$$

$$Z_{11} \begin{cases} 1 & \text{3rd quarter} \\ 0 & \text{not 3rd quarter} \end{cases}$$

$$Z_{12} \begin{cases} 1 & \text{4th quarter} \\ 0 & \text{not 4th quarter} \end{cases}$$

STATISTICAL ESTIMATION

Method of Estimation

Since each equation was over identified, Two-Stage Least Squares (2SLS), a single equation approach, and Three-Stage Least Squares (3SLS), a simultaneous equation approach, were the estimation methods used. Both estimation methods yield consistent estimates.[13]

Estimated Structures

Estimates of the slope parameters obtained for the equations in Models I and II, the t ratios, the standard error of estimate s, and the Durbin-Watson d statistic are listed by dependent variables in Tables 3-7.

The t ratios, which are in parentheses, are ratios of the estimated slopes to their respective estimated standard errors. They do not have the t distribution in a simultaneous equations model but they are approximately normal so that large values may indicate a degree of statistical significance in a crude test of whether the relevant variable belongs in the equations.[14] Accordingly, inferences about the slope parameters were based on tests that are at best only approximate.

Estimates—Demand for Shell Eggs Equation

Data in Table 3 show that, for both 2SLS and 3SLS and for Models I and II, an increase in the New York wholesale price of shell eggs led to a decrease in the use of shell eggs, a rise in the wholesale price index led to a rise in the demand for shell eggs, and an increase in the movement of eggs into retail channels in the previous month over the same month a year ago led to a decrease in the demand for shell eggs.

[13]The procedures for estimating the structural coefficients by two-stage and three-stage least squares have been adequately treated in several econometric textbooks, e.g., A. S. Goldberger, Econometric Theory, John Wiley and Sons, New York, 1964.

[14]Christ, Carl F. 1966. Econometric Models and Methods. John Wiley and Sons, New York, p. 598.

TABLE 3.—Estimates of the Demand for Shell Eggs Equation. Dependent Variable: Y_1. Period: 1962-1967.

Estimation Method	Model	Coefficients (and t Ratios)* of									s	d
		Y_3	Z_1	Z_3	Z_4	Z_9	Z_{10}	Z_{11}	Z_{12}	α		
Two-Stage Least Squares	I	— 1.5030	1.7410	—0.1472	1.134	— 0.1220	—	—	—	18.23	3.727	0.849
		(— 8.308)	(9.138)	(—1.457)	(7.793)	(— 4.614)				(— 0.9667)		
Three-Stage Least Squares	I	— 1.5940	1.8960	—0.1630	1.1580	— 0.0616	—	—	—	— 9.863	—	—
		(—17.130)	(11.250)	(—3.929)	(13.200)	(— 3.591)				(— 0.5820)		
Two-Stage Least Squares	II	— 1.9200	1.6870	—0.2545	1.1790	— 0.0799	—11.6400	— 1.280	— 0.9539	31.54	2.486	1.743
		(— 9.491)	(11.870)	(—3.501)	(8.174)	(— 2.307)	(—11.630)	(— 1.091)	(— 0.5994)	(2.441)		
Three-Stage Least Squares	II	— 1.6410	1.6530	—0.1797	0.9005	— 0.0399	—11.6300	— 2.3890	0.5209	25.02	—	—
		(—11.320)	(12.180)	(—3.765)	(9.038)	(— 1.437)	(—12.120)	(— 2.372)	(0.3792)	(2.075)		

*Required t's for the .05 level of significance: one-tailed test, 1.67; two-tailed test, 2.00.

TABLE 4.—Estimates of Demand for Breaking Eggs Equation. Dependent Variable: Y_2. Period: 1962-1967.

Estimation Method	Model	Coefficients (and t Ratios)* of									s	d
		Y_4	Z_1	Z_2	Z_4	Z_5	Z_{10}	Z_{11}	Z_{12}	α		
Two-Stage Least Squares	I	— 1.8200	0.1842	— 0.0360	— 0.9139	1.4710	—	—	—	31.93	3.317	1.517
		(— 1.517)	(0.8714)	(— 3.710)	(— 4.679)	(4.655)				(1.817)		
Three-Stage Least Squares	I	— 1.6390	0.2256	— 0.0302	— 0.6866	0.9002	—	—	—	29.0700	—	—
		(— 2.084)	(1.312)	(— 3.992)	(— 5.056)	(5.046)				(1.848)		
Two-Stage Least Squares	II	— 2.7280	0.4123	— 0.0517	— 0.5851	1.2480	6.0070	1.3120	4.2490	16.7200	2.234	1.795
		(— 2.741)	(2.451)	(— 3.421)	(— 4.179)	(5.575)	(6.515)	(1.692)	(2.552)	(1.408)		
Three-Stage Least Squares	II	— 1.9930	0.3594	— 0.0415	— 0.4933	0.9506	6.9610	1.4070	2.8270	13.940	—	—
		(— 2.421)	(2.450)	(— 3.168)	(— 4.292)	(5.311)	(7.827)	(1.822)	(1.873)	(1.219)		

*Required t's for the .05 level of significance: one-tailed test, 1.67; two-tailed test, 2.00.

This relation lends support to the view that there is a tendency for increased purchases of shell eggs in the past period to satisfy some of the current period egg requirements.

The data in Table 3 indicate also that a rise in the price of shell eggs in the past month led to a rise in current demand for shell eggs and that an increase in the number of layers on U. S. farms over 9 months old led to a decrease in the demand for shell eggs, implying that buyers postpone purchases of shell eggs in anticipation of lower prices.

All of these relations appeared reasonable and the estimates obtained by 2SLS were fairly close to those obtained by 3SLS with the exception of the coefficients of Z_9. For Model I, the 2SLS coefficient of Z_9 was 98 percent larger than the 3SLS coefficient. It was 200 percent larger than the 3SLS coefficient in Model II. Only the 2SLS coefficient of Z_3 in Model I and the 3SLS coefficient of Z_9 in Model II were not significantly different from zero.

From Model II, the demand for shell eggs decreased substantially in the second quarter over the first but decreased only moderately in the third quarter over the first. The 2SLS version of Model II showed that fourth quarter demand for shell eggs declined relative to first quarter demand, while the 3SLS version indicated that fourth quarter demand for shell eggs increased relative to the first quarter. On the basis of Figure 6 and Appendix B, Table VII, the 2SLS relation appears reasonable. The 2SLS coefficient of Z_{11} and both the 2SLS and 3SLS coefficients of Z_{12} were not supported statistically.

The elasticities of demand for shell eggs at the wholesale level obtained from 2SLS and 3SLS estimates for Model I and Model II are shown in Table 5. Model II elasticities were larger than those of Model I. From Model II, 2SLS, a 1 percent increase in the New York price of shell eggs resulted in a decrease in shell use of .49 percent.

Estimates—Demand for Breaking Eggs Equation

Model I and Model II results for the demand for breaking eggs equation obtained by two-stage and three-stage least squares and listed in Table 4 appeared reasonable and showed no wrong signs. The estimates showed some variation. For two-stage least squares, the Model II coefficient of Y_4 was 50 percent larger than Model I. The two-stage least squares coefficients of Y_4 and Z_1 and the three-stage least squares coefficient of Z_1 in Model I were not significantly different from zero. Breaking egg utilization varied inversely with the price of breaking eggs —Chicago standards and farm run. A rise in the index of wholesale prices also raised the demand for breaking eggs but an increase in the number of pullets hatched 6 to 21 months ago resulted in a decrease in the demand for breaking eggs. The implication is that breakers tend to hold off purchases of eggs in anticipation of lower prices which may result from the pressure of increasing supplies of eggs. A rise in the price of shell eggs lagged 1 month reduced the demand for breaking eggs. On the other hand, an increase in the price of egg products lagged 1 month led to an increase in the use of breaking eggs. It would appear that breakers expect current prices to move in the same direction as past prices and tend to make their decisions on this basis.

The demand for breaking eggs in the second quarter was considerably higher than in the first quarter. Third quarter break, although larger, did not differ greatly from the first quarter. The demand for breaking eggs in the fourth quarter appears higher than in the first quarter but this relation did not appear to be reasonable. The coefficients of Z_{10}, Z_{11}, and Z_{12} were significantly different from zero.

On the basis of the two-stage least squares results of Model II, the elasticity of demand for breaking eggs at the wholesale level of marketing was computed to be —1.27. For three-stage least squares, the elasticity of demand for breaking eggs was —1.49. These elasticities were considerably larger than those for shell eggs (Table 5). A likely reason for this may lie in the storable characteristic of egg products, which assures breakers flexibility over time in procurement when fulfilling advance or order sales.

TABLE 5.—Comparison of Price Elasticities of Demand at Wholesale Obtained by Different Estimation Procedures for Models I and II, 1962-67.

Variable	Identification	Estimation Procedure	Model I	Model II
Shell Egg Utilization	Y_1	Two-stage least squares	— .38	— .49
		Three-stage least squares	— .40	— .41
Breaking Egg Utilization	Y_2	Two-stage least squares	— .92	—1.27
		Three-stage least squares	— .83	—1.49

TABLE 6.—Estimates of the Supply of Shell Eggs Equation. Dependent Variable: Y_1. Period: 1962-1967.

Estimation Method	Model	Coefficients (and t Ratios)* of Y_3	Y_4	Z_6	Z_7	Z_{10}	Z_{11}	Z_{12}	a	s	d
Two-Stage Least Squares	I	1.7620	— 4.3890	0.8005	0.9577	—	—	—	—45.1900	4.266	0.539
		(5.661)	(— 4.267)	(4.134)	(8.618)				(— 1.741)		
Three-Stage Least Squares	I	1.1620	— 2.3130	0.5910	0.8453	—	—	—	—16.1200	—	—
		(5.129)	(— 3.313)	(4.565)	(9.432)				(— 0.8015)		
Two-Stage Least Squares	II	0.8595	— 2.4270	0.4347	0.7229	— 7.2190	— 5.5840	1.2850	22.5400	2.612	1.546
		(3.728)	(— 3.216)	(3.190)	(11.000)	(— 6.522)	(— 4.036)	(1.065)	(1.407)		
Three-Stage Least Squares	II	0.6200	— 2.1250	0.2149	0.6424	— 8.1090	— 6.5560	0.6159	49.020	—	—
		(3.315)	(— 3.591)	(2.080)	(11.580)	(— 7.711)	(— 5.259)	(0.5492)	(3.810)		

*Required t's for the .05 level of significance: one-tailed test, 1.67; two-tailed test, 2.00.

TABLE 7.—Estimates of the Supply of Breaking Eggs Equation. Dependent Variable: Y_2. Period: 1962-1967.

Estimation Method	Model	Coefficients (and t Ratios)* of Y_3	Y_4	Z_6	Z_7	Z_{10}	Z_{11}	Z_{12}	a	s	d
Two-Stage Least Squares	I	— 1.6120	3.3180	— 1.7400	— 0.1267	—	—	—	75.2800	4.123	0.471
		(— 5.357)	(3.337)	(— 0.9298)	(— 1.179)				(2.999)		
Three-Stage Least Squares	I	— 1.0110	1.2450	0.0236	— 0.0186	—	—	—	47.2100	—	—
		(— 4.546)	(1.805)	(0.1824)	(— 0.2132)				(2.402)		
Two-Stage Least Squares	II	— 0.9299	2.1040	0.3232	0.1022	6.5590	7.5250	1.0920	5.260	2.711	1.356
		(— 3.884)	(2.685)	(2.284)	(1.497)	(5.706)	(5.239)	(0.8719)	(0.3162)		
Three-Stage Least Squares	II	— 0.6505	1.6480	0.5091	0.1759	7.5940	8.0980	1.4620	—19.2000	—	—
		(— 3.315)	(2.632)	(4.638)	(3.037)	(6.951)	(6.227)	(1.252)	(— 1.420)		

*Required t's for the .05 level of significance: one-tailed test, 1.67; two-tailed test, 2.00.

Results—Supply of Shell Eggs Equation

The relations in the supply of shell eggs equation also appeared reasonable. There were no wrong or conflicting signs. Model I coefficients were larger, however, than those of Model II. To illustrate, the two-stage least squares coefficient of Y_3 for Model I was twice as large as the corresponding two-stage least squares coefficient for Model II. All of the coefficients with the exception of Z_{12} were significantly different from zero (Table 6).

Table 6 also shows that an increase in the price of shell eggs, New York, increased the quantity of eggs allocated to shell use but that an increase in the price of breaking eggs, Chicago standards and farm run, decreased shell egg allocations. The number of eggs allocated to the shell egg market was increased more by an increase in egg production in the other states than by an equivalent increase in egg production in the West North Central region.

From Model II results, allocations of eggs to the shell market were substantially reduced in the second and third quarters in relation to the first quarter. However, fourth quarter allocation to the shell egg market was higher than the first quarter.

Computed at the means from Model II two-stage least squares estimates, a 1 percent increase in the New York wholesale price of shell eggs increased the marketing of shell eggs by .22 percent, while a 1 percent increase in breaking egg prices, Chicago standards and farm run, decreased allocations to the shell egg market by .13 percent. Elasticities obtained from Model I results were generally larger than those obtained from Model II results and those computed from three-stage least squares were smaller than those from two-stage least squares (Table 9).

The low elasticities may be explained by: (1) the relatively high quality requirements of the shell egg market so that eggs have to be produced specially for this market and (2) the tendency of egg suppliers to be committed to certain shell egg buyers either by formal or informal contractual arrangements.

Results—Supply of Breaking Eggs Equation

As shown in Table 7, an increase in the New York price of shell eggs decreased the number of eggs available to breakers, but an increase in the price of breaking eggs, Chicago standards and farm run, resulted in an increase in the quantity of breaking eggs supplied. All of these relations were reasonable and all coefficients of Y_3 and Y_4 were significantly different from zero.

A 1 percent increase in the New York price of shell eggs decreased the number of eggs sold to breakers by 2.13 percent, while a 1 percent advance in the price of breaking eggs, Chicago standards and farm run, increased egg sales to breakers by 1.06 percent (Table 9).

These elasticities computed at the mean from the supply of breaking egg equations were larger than those based on the supply of shell eggs equations. This phenomenon may arise: (1) if breaking utilization is in effect a residual claimant on the total supply of eggs, (2) because the requirements for breaking eggs are not as exacting or as exclusive as those for shell eggs, and (3) because of the tendency of suppliers of shell eggs to have formal or informal arrangements with specific shell egg buyers.

The two-stage least squares results for Model I in Table 7 indicated that an increase in egg production in both the West North Central region and in the other states decreased the supply of eggs for breaking. These relations were unreasonable and, in addition, were not supported statistically. Both of these relations in the three-stage least squares version of Model I were not supported statistically but only the coefficient of Z_7 had the wrong sign. Estimates from both the two-stage least squares and the three-stage least squares versions of Model II indicated that at given prices, an increase in egg production in the West North Central region increased the supply of eggs available for breaking more than did a corresponding increase in egg production in the other states.

A sizeable proportion of the eggs produced in the West North Central region are from small farm flocks and do not meet the quality requirements of the shell market. There is also the fact that the West North Central region is still the major egg breaking and solids production area. Thus the eggs from this region which meet the shell market requirements can shift, depending on relative net returns, between the shell and the breaking egg markets. For these reasons, egg production in the other states cannot be expected to have as important a direct effect on egg sales to breakers.

As in Model I, the two-stage least squares coefficient of Z_7 was not significantly different from zero.

The unreasonable relations in the supply of breaking eggs equation in Model I, an obvious defect of this model, were resolved or corrected in Model II by the inclusion (in the corresponding equation) of dummy variables representing seasonal influences. Sales of eggs to breakers increased substantially in the second and third quarters over sales in the first quarter, while the model implied that allocations of eggs to breakers in the fourth quarter increased moderately over the first quarter allocations. However, both the two-stage and the three-stage least squares coefficients of Z_{12} were not significantly different from zero.

TABLE 8.—Estimates of the Iowa Farm Price Relation. Dependent Variable Y_5. Period: 1962-1967.

Estimation Method	Model	Coefficients (and t Ratios)* of									
		Y_3	Y_4	Z_6	Z_8	Z_{10}	Z_{11}	Z_{12}	a	s	d
Two-Stage Least Squares	I	0.6274	1.1280	— 0.0745	— 4.105	—	—	—	6.118	2.202	2.015
		(4.979)	(2.193)	(— 0.6638)	(— 0.8542)				(0.3931)		
Three-Stage Least Squares	I	0.4901	1.6500	— 0.1306	— 6.7340	—	—	—	15.1800	—	—
		(4.171)	(3.444)	(— 1.252)	(— 1.506)				(1.049)		
Two-Stage Least Squares	II	0.6559	0.9708	— 0.1498	— 1.1080	0.2078	— 1.1080	0.0052	13.02	2.159	2.079
		(4.185)	(1.660)	(— 1.078)	(— 0.9256)	(0.2283)	(— 0.9256)	(0.0050)	(0.7709)		
Three-Stage Least Squares	II	0.5321	1.3160	— 0.1204	— 5.5490	— 0.2708	— 0.4782	0.4843	13.2700	—	—
		(3.511)	(2.318)	(— 0.9031)	(— 1.176)	(— 0.3007)	(— 0.4071)	(0.4776)	(0.8205)		

*Required t's for the .05 level of significance: one-tailed test, 1.67; two-tailed test, 2.00.

Estimates—Iowa Farm Price Equation

The Iowa farm price was increased by an increase in shell egg prices and by an increase in breaking egg prices but decreased by an increase in egg production in the West North Central region and by an increase in wage rates. The coefficients of Y_3, Y_4, Z_6, and Z_8 all have correct signs for both methods and for both models. None of the coefficients of Z_6 and Z_8 were statistically different from zero. The two-stage least squares coefficient of Y_4 (Model II) was not supported statistically (Table 8).

On the basis of the two-stage least squares results for Model II, a 1 percent increase in the New York price of shell eggs led to an increase of .92 percent in the Iowa farm price, while a similar increase in the price of breaking eggs, Chicago standards and farm run, only resulted in an increase of .30 percent in the Iowa farm price. For Model II, responses computed from 3SLS estimates differed from those from 2SLS. For comparison, the 3SLS results showed that a 1 percent increase in shell egg prices and a 1 percent increase in breaking egg prices resulted in the respective increases of .75 percent and .41 percent in Iowa farm prices (Table 9).

Iowa farm prices increased in the second and fourth quarters but decreased in the third quarter relative to the first quarter. The 3SLS version of Model II showed that Iowa farm prices decreased in the second and third quarters and increased in the fourth quarter relative to the first. In other words, the 2SLS coefficient of Z_{10} had a different sign from the 3SLS coefficient. The 3SLS coefficient appeared to be reasonable.

To appraise the two econometric models and their estimates, certain tests of hypotheses must be carried out. One hypothesis already tested (at the .05 probability level) in the preceding discussion of estimated structures was whether a given predetermined variable does (or does not) appear in an equation.

Both models assumed that the residuals, u's, were serially independent. An approximate test of this assumption may be made on the 2SLS versions with the Durbin-Watson d statistic. The upper limit du for the Durbin-Watson serial correlation test is approximately suitable for establishing acceptance regions. The appropriate value of K for the Durbin-Watson test here is the number of explanatory variables in the reduced form, not counting the constant term. The Durbin-Watson table shows values of K no larger than 5, so it will not provide a conclusive test.[15]

[15]See Carl F. Christ, **op. cit.**, pp. 521-31.

Table 10 shows that for two-stage least squares estimates in Model I, positive serial correlation was indicated for the demand for shell eggs equation, the supply of shell eggs equation, the demand for breaking eggs equation, and the supply of breaking eggs equation, while the hypothesis of serial independence was accepted for the Iowa farm price equation. For the two-stage least squares results of Model II, positive serial correlation was indicated for the demand for shell eggs equation, the supply of shell eggs equation, and the supply of breaking eggs equation, but the assumption of serial independence was satisfied for the demand for breaking eggs equation and for the Iowa farm price equation.

ANALYSES AND PREDICTIONS

In this section, estimates of the reduced forms of the two models are presented and analyzed since it is the reduced forms of the models, derived from the structural estimates, which are of immediate concern in making conditional forecasts or predictions and economic policy decisions.

The reduced form of statement (33) was written:

$$Y'_t = \pi Z'_t + \alpha'_t + v'_t \qquad (34)$$

where $\pi = -B^{-1}\,\Gamma$

$\alpha'_t = -B^{-1}\,A'_t$

$v'_t = -B^{-1}\,U'_t$

TABLE 9.—Percent Change in the Supply of Shell Eggs, Supply of Breaking Eggs, and Iowa Farm Price for a Given Change in Prices of Shell and Breaking Eggs.

1 Percent Change in		Method	Model I	Model II
			Percent Change in the Supply of Shell Eggs	
Shell Egg Price	Y_3	2SLS	0.45	0.22
		3SLS	0.29	0.16
Breaking Egg Price	Y_4	2SLS	−0.24	−0.13
		3SLS	−0.13	−0.12
			Percent Change in the Supply of Breaking Eggs	
Shell Egg Price	Y_3	2SLS	−3.70	−2.13
		3SLS	−2.32	−1.49
Breaking Egg Price	Y_4	2SLS	1.67	1.06
		3SLS	0.63	0.83
			Percent Change in Iowa Farm Price	
Shell Egg Price	Y_3	2SLS	0.88	0.92
		3SLS	0.68	0.75
Breaking Egg Price	Y_4	2SLS	0.35	0.30
		3SLS	0.51	0.41

TABLE 10.—Observed Durbin-Watson Statistics d and the 5 Percent Acceptance Region Based on the Upper Limit du for K=5 and T=72 2SLS Version, Models I and II.*

	Acceptance Region		Observed d's	
Equation	du	4-du	I	II
Demand for Shell Eggs	1.77	2.23	.849	1.743
Supply of Shell Eggs	1.77	2.23	.539	1.546
Demand for Breaking Eggs	1.77	2.23	1.517	1.795
Supply of Breaking Eggs	1.77	2.23	.471	1.356
Iowa Farm Price	1.77	2.23	2.015	2.079

*K=the number of predetermined variables excluding the constant term, T=the number of observations.

TABLE 11.—Reduced Form Estimates of Model I, Solved Two-Stage and Three-Stage Versions of the Structure.

Dependent Variable	Estimation Method	Coefficients of									
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	α
Y_1	Two-stage least squares	0.2298	0.0245	−0.0300	0.8527	−1.0003	0.5189	0.6762	0	−0.0249	−2.7782
	Three-stage least squares	0.1940	0.0198	−0.0294	0.6603	−0.5916	0.4998	0.6805	0	0	−3.0684
Y_2	Two-stage least squares	−0.4552	−0.0139	0.0445	−0.6970	0.5699	0.1355	0.2120	0	0.0369	39.3043
	Three-stage least squares	−0.5161	−0.0059	0.0481	−0.4758	0.1754	0.1936	0.2347	0	0	41.8282
Y_3	Two-stage least squares	1.0055	−0.0163	−0.0780	0.1871	0.6656	−0.3453	−0.4499	0	−0.0646	13.9775
	Three-stage least squares	1.0677	−0.0124	−0.0838	0.3122	0.3712	−0.3136	−0.4269	0	0	−4.2626
Y_4	Two-stage least squares	0.3513	−0.0121	−0.0245	−0.1192	0.4951	−0.0745	−0.1165	0	−0.0203	−4.0518
	Three-stage least squares	0.4525	−0.0148	−0.0294	−0.1286	0.4422	−0.1181	−0.1432	0	0	−7.7842
Y_5	Two-stage least squares	1.0271	−0.0239	−0.0765	−0.0170	0.9761	−0.3751	−0.4137	−4.1050	−0.0634	10.3170
	Three-stage least squares	1.2700	−0.0305	−0.0895	−0.0592	0.9116	−0.4791	−0.4455	−6.7340	0	0.2470

TABLE 12.—Reduced Form Estimates of Model II, Solved Two-Stage and Three-Stage Versions of the Structure.

		Coefficients of												
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	a
Y_1	2SLS	0.1143	0.0216	−0.0432	0.4441	−0.5205	0.4957	0.6428	0	−0.0136	−7.7390	−2.2625	−0.4115	19.2881
	3SLS	0.0282	0.0211	−0.0230	0.3662	−0.4839	0.4466	0.6449	0	−0.0005	−8.2366	−2.6175	−0.0911	29.0833
Y_2	2SLS	−0.2505	−0.0166	0.0578	−0.4557	0.4011	0.3180	0.2335	0	0.0181	7.3853	4.5510	2.6150	6.8999
	3SLS	−0.1899	−0.0142	0.0340	−0.3392	0.3253	0.3756	0.2373	0	0.0008	8.0438	5.0199	1.9470	−3.3184
Y_3	2SLS	0.8191	−0.0112	−0.1101	0.3828	0.2711	−0.2582	−0.3348	0	−0.0346	−2.0317	0.5117	−0.2825	6.3812
	3SLS	0.9901	−0.0129	−0.0955	0.3256	0.2949	−0.2722	−0.3960	0	−0.0021	−2.0679	0.1392	0.3730	2.4761
Y_4	2SLS	0.2430	−0.0129	−0.0219	−0.0474	0.3104	−0.1166	−0.0856	0	−0.0067	−0.5052	−1.1873	0.5990	3.5997
	3SLS	0.2756	−0.0137	−0.0171	−0.0773	0.3138	−0.1884	−0.1191	0	−0.0004	−0.5433	−1.8128	0.4415	8.6595
Y_5	2SLS	0.7731	−0.0199	−0.0927	0.2050	0.4792	−0.4323	−0.3027	−5.7370	−0.0291	−1.6153	−1.9250	0.4014	20.7000
	3SLS	0.8895	−0.0248	−0.0733	0.0715	0.5698	−0.5132	−0.3674	−5.5490	−0.0016	−2.0861	−2.7898	1.2638	23.3484

In the structural form, each equation is intended to represent the behavior of some unit of the economy and the structural coefficient indicates only a direct effect within a single sector of the economy. The solved or derived reduced form coefficient (multiplier) indicates the "total" effect of a change in the predetermined variable, Z_t, on an endogenous variable, Y_t, after taking account of the interdependencies among the current endogenous variables, with the other predetermined variables held constant. To illustrate, egg product prices lagged 1 month, Z_5, did not directly influence shell egg utilization, Y_1, but the total effect of a 1 cent increase in the lagged egg price (through breaking egg utilization, Y_2) was to induce an estimated decrease for Model I (2SLS) of 1.003 million eggs in average daily shell egg utilization (Table 11).

Notice that the two-stage and three-stage multipliers of Iowa farm price, Y_5, with respect to the lagged New York shell egg price, Z_4, in Model I, carried opposite signs to those in Model II, and that the two-stage and three-stage multipliers of Y_3 on Z_{12} differed in signs. The reduced form estimates or multipliers are shown in Tables 11 and 12.

Analyses

Since Model II was preferred to Model I, the discussion of the analysis of the interrelationships of the important variables in the system was confined to the impact multipliers of Model II and only to the two-stage least squares estimates (Table 12).

The effect of a 1 percentage point increase in the wholesale price index with the other predetermined variables held constant will be to: (1) increase daily shell egg utilization by 114,000 eggs, (2) decrease daily breaking egg utilization by 250,000 eggs, (3) increase the price of shell eggs per dozen by 0.8 cent, (4) increase the price of breaking eggs by 24 cents per case or 0.8 cent per dozen, and (5) increase the Iowa farm price per dozen by about 0.8 cent.

The estimates of the multipliers for the number of chicks hatched 6 to 21 months ago (the indicator of existing supplies of eggs to breakers) imply that an increase of 1 million chicks hatched 6 to 21 months ago, with all other predetermined variables in the system held constant, is associated with: (1) an increase of approximately 22,000 eggs in average daily shell egg use, (2) a decrease of about 17,000 eggs in average daily breaking egg use, (3) a decrease of 0.1 cent per dozen in the shell egg price, (4) a decrease of 1 cent per case in the price of breaking eggs, and (5) a decrease of about 0.2 cent per dozen in the Iowa farm price.

A 1 percentage point increase in the movement of eggs into retail channels in the previous month over the same month a year ago is expected to decrease average daily current shell egg use by 43,000 eggs, increase average daily breaking egg use by about 58,000 eggs, decrease shell egg price by 0.1 cent per dozen, decrease breaking egg price by 2 cents per case, and decrease Iowa farm price by 0.9 cent per dozen.

The effect of a unit increase in shell egg price lagged 1 month, Z_4, other variables held constant, is to lead to an increase in average daily shell egg use of 444,000 eggs but to a decrease in average daily breaking egg use of 456,000 eggs. It also will lead to increases of about 0.4 cent in the price of shell eggs and of 0.2 cent in the Iowa farm price but to a decrease in the price of breaking eggs of 4 cents per case.

A 1 cent per pound increase in egg product prices, Z_5, is expected to lead to a decrease of 52,000 eggs in the average daily use of shell eggs, an increase of 40,000 eggs in the average daily use of breaking eggs, an increase of about 0.3 cent per dozen in the price of shell eggs, an increase of 31 cents per case in

TABLE 13.—Measure of Predictive Accuracy: Algebraic Mean Forecast Errors and Theil U Coefficients, 1967, from Solved Reduced Forms of Models I and II, Given Correct Values of the Predetermined Variables.

Variable		Method	Algebraic Mean Error		Theil U Value	
			Model I	Model II	Model I	Model II
Shell Egg Use	Y_1	2SLS	0.1723	−0.3112	.0100	.0062
		3SLS	−2.9819	−1.9216	.0139	.0085
Breaking Egg Use	Y_2	2SLS	−0.1769	0.4901	.0606	.0428
		3SLS	4.8399	2.7211	.1557	.0860
Shell Egg Price	Y_3	2SLS	0.2453	−0.5144	.0467	.0405
		3SLS	−8.5119	−10.4113	.1206	.1406
Breaking Egg Price	Y_4	2SLS	0.0759	−0.0652	.0695	.0469
		3SLS	−2.8483	−0.9110	.1741	.0758
Iowa Farm Price	Y_5	2SLS	0.7061	−0.9998	.0661	.0512
		3SLS	−8.5274	4.1097	.1676	.0951

TABLE 14.—Measure of Predictive Accuracy: Algebraic Mean Forecast Errors and Theil U Coefficients for Solved Reduced Forms of Models I and II, January to June, 1968.

Variable		Method	Algebraic Mean Error		Theil U Value	
			Model I	Model II	Model I	Model II
Shell Egg Use	Y_1	2SLS	−2.0242	−0.0192	.0096	.0063
		3SLS	−4.3338	−1.4745	.0157	.0082
Breaking Egg Use	Y_2	2SLS	−0.1059	0.1756	.0555	.0479
		3SLS	4.5445	1.8905	.1501	.0820
Shell Egg Price	Y_3	2SLS	1.8838	−0.0726	.0456	.0275
		3SLS	−8.9494	−10.4574	.1261	.1430
Breaking Egg Price	Y_4	2SLS	0.8069	−0.0755	.0851	.0305
		3SLS	−2.8439	−1.2050	.1801	.0927
Iowa Farm Price	Y_5	2SLS	2.6367	0.1882	.0811	.0285
		3SLS	−7.9746	−4.0312	.1652	.0931

the price of breaking eggs, and an increase of about 0.5 cent per dozen in the Iowa farm price, other variables remaining unchanged.

The estimates of the second quarter multipliers indicate that daily shell egg utilization in the second quarter is 7.7 million eggs less than in the first quarter but daily breaking egg utilization in the second quarter is 7.4 million eggs greater than in the first quarter. These estimates also indicate that the New York price of shell eggs in the second quarter is 2 cents per dozen lower than in the first quarter and that the price of breaking eggs is also 50 cents per case lower than in the first quarter. Second quarter Iowa farm prices are 1.6 cents per dozen lower than the first quarter, other predetermined variables held constant.

Lower shell egg use in the second quarter accompanied by lower shell egg prices indicates that the demand for shell eggs in the second quarter is substantially lower than in the first quarter. Increased breaking egg use in the second quarter (the major egg breaking season) coincides with this period of low shell egg demand and occurs at the time that both shell and breaking egg prices are at seasonal lows. It appears that breaking operations in the major breaking season provide an alternative market for eggs which become available as a result of the lower shell egg demand and in consequence act as a buffer for shell egg prices. The level of breaking egg prices, therefore, appears to be closely linked to that of shell eggs and breaking egg utilization appears to be a residual claimant on egg supplies.

It has been argued that "to get supplies during the heavy breaking season (second quarter), egg breakers frequently bid producers away from shell egg plants."[16] Logically then, shell egg use would be expected to decrease, while breaking egg use, shell egg prices, and breaking egg prices would be expected to increase. The results of the estimates of the multipliers or solved reduced form coefficients of Z_{10} indicate lowered demand for shell eggs encourages heavier breaking egg activity in the second quarter.

Estimates of the multipliers or solved reduced form coefficients for the other predetermined variables may be interpreted in the same manner.

Predictions

Economic predictions can be made for the guidance of economic policy making or for the purpose of testing the hypotheses embodied in a model.

To test which version (two-stage or three-stage least squares) and which one of the two models best fitted the data for the sample period, predictions of the endogenous variables conditional on the 1967 values of the predetermined variables were made from the solved reduced forms of the equations. The errors of forecast were then compared.

It is often argued that the acid test of an econometric model or equation is its ability to predict (or even describe) data which were not used in its construction and estimation. On this basis, the procedure employed above may be faulted as not valid. An alternative approach to the use of all data would be to separate the data into two parts, using one part to estimate the parameters and the other part for a test of the estimated model's predicting ability. Regardless of which approach is used, the best result which could emerge would be an estimated model which agrees closely with data for the entire period 1962-1967. There is no more assurance that the agreement will extend to post-1967 data whether close agreement is secured by fitting the model in 1968 to all of the 1962-1967 data or choosing a model in 1968 and fitting it to data for half of the period and successfully predicting data for the other half of the period. The test lies, however, in confronting the model with an entirely new set of data which was not familiar when the model was chosen. Accordingly, the models were confronted with data (the first half of 1968) which were not known when the study was started and their predictive abilities were compared (Table 14).[17]

In evaluating the predictive ability of a model (that is, the accuracy of its forecast), the correlation coefficient between the predicted and the observed values has sometimes been used. A high correlation coefficient between predicted and observed values does not always imply a good prediction; consequently, an alternative measure of predictive accuracy was proposed by Theil:[18]

$$U = \frac{\sqrt{1/n \sum_{t=1}^{n} (Y_t^* - Y_t)^2}}{\sqrt{1/n \sum_{t=1}^{n} Y_t^{*2}} + \sqrt{1/n \sum_{t=1}^{n} Y^2_t}} \qquad (35)$$

where Y_t^* = the predicted value at time t and Y_t = the observed value at time t. The Theil U coefficient has the property of varying between zero and one; the higher the overall predictive accuracy, the closer is the U coefficient to zero.

The Theil U values measure only the overall accuracy of the predictions. They do not provide de-

[16] See Rogers and Conley, **op cit.**, pp. 336-37.

[17] Carl F. Christ, **op. cit.**, p. 546.

[18] Theil, H. 1961. Economic Forecasts and Policy. North Holland Publishing Co., Amsterdam.

tailed information about the direction of prediction errors. One way of indicating the direction of the prediction errors is to plot the predicted values Y_t^* against the corresponding observed values Y_t. Another way is to compute the algebraic mean forecast error:

$$1/n \sum_{t=1}^{n} v_t^*$$

where v_t^* is the forecast error for time t. The sign of the algebraic mean forecast error is indicative of the tendency of the model to over or underestimate.

The Theil U values and the algebraic mean forecast errors computed for the endogenous variables for both the two-stage and three-stage least squares versions of both models are given in Table 13. The data in Table 13 clearly indicate that the forecast errors for the solved two-stage least squares structure were smaller than the forecast errors for the solved three-stage structure. This implied that the two-stage least squares versions yielded more accurate predictions than the three-stage least squares version. The Theil U value and the algebraic mean error were smaller for Model II than for Model I. The solved two-stage least squares structure of Model II yielded the smallest forecast errors in predicting the conditional values of the endogenous variables in 1967. On the basis of overall predictive performance, two-stage least squares Model II was preferred.

The algebraic mean error for the solved three-stage least squares structure of Model I was negative for shell egg use, shell egg price, breaking egg price, and Iowa farm price and positive for breaking egg use. This indicated a tendency for Model I in 1967 to predict too high on the average for the first four variables and too low for breaking egg use.

Two-stage least squares Model II tended to predict too high (as indicated by the negative sign on the algebraic mean error for the solved structure) for shell egg use, shell egg price, breaking egg price, and Iowa farm price and too low for breaking egg use. The predictive performance of two-stage least squares Model I was the exact opposite.

An important application of an econometric model is in predicting future values of the endogenous variables in the system, while the acid test of the model, as indicated earlier, is its ability to predict data which were not used in its construction or estimation. One objective of this study was to demonstrate the ability of the models to predict future values of the endogenous variables.

Accordingly, conditional predictions were obtained for the first 6 months of 1968 from the solved reduced forms of the two-stage and three-stage least squares structures of Models I and II. Theil U values and algebraic mean forecast errors were then computed.

The Theil U values indicated that predictions for the first 6 months of 1968 obtained from the solved two-stage least squares structures tended to have smaller prediction errors than those obtained from the solved three-stage least squares structures and that those obtained from Model II had smaller prediction errors than those from Model I (Table 14). The evidence demonstrated that the solved two-stage least squares structure of Model II tended to yield more accurate predictions of the endogenous variables in the system than the other structures appraised.

The solved three-stage least squares structures showed a tendency to overestimate by a relatively wide margin all the endogenous variables in the system with the exception of the variable breaking egg use, Y_1, which was underestimated. The variables shell egg price, Y_3, and breaking egg price, Y_4, were underestimated by the solved two-stage least squares structure in Model I but overestimated by this structure in Model II (Table 14).

The conditional predictions for January to June 1968 and the forecast errors for the solved two-stage least squares structure of Model II are listed in Table 15. The Theil U values indicated that the predictions from the solved two-stage least squares structure, Model II, of shell egg use for the first half of 1968 tended to have smaller prediction errors than predictions of other endogenous variables in the system. The negative values for the algebraic mean error indicated that the model displayed a tendency to predict on the average slightly high for shell egg use, shell egg price, and breaking egg price but to predict too low on the average for breaking egg use and Iowa farm price (Table 15).

No attempt was made in this study to obtain predictions of the endogenous variables in future time periods. This exercise will be the subject of another report which also will include (1) a comparison of ordinary least squares estimates and predictions with those of the models discussed in this report and (2) a discussion of the methods of obtaining or estimating the values of the predetermined variables to be used in making these predictions.

TABLE 15.—Conditional Predictions, Forecast Errors for the Solved Two-Stage Least Squares Structure Model II for January to June, 1968, Theil U Values, and Algebraic Mean Errors.

Variable	Prediction and Error	Jan.	Feb.	Mar.	April	May	June	Theil U	Algebraic Mean Error
Shell Egg Use	Prediction	167.1	166.5	167.7	162.3	157.9	153.4		
Y_1								.0063	—.0192
Millions Daily	Error	—0.05	—2.73	—1.10	3.19	2.04	—1.47		
Breaking Egg Use	Prediction	13.7	15.2	17.2	23.6	24.4	24.5		
Y_2								.0479	.1756
Millions Daily	Error	1.59	1.88	1.32	—2.93	—2.11	1.31		
Shell Egg Price	Prediction	33.68	33.39	31 80	30.49	30.38	31.48		
Y_3								.0275	—.0726
Cents per Dozen	Error	—0.58	—0.24	1.40	1.41	—2.18	1.92		
Breaking Egg Price	Prediction	6.26	6.74	6.71	6.02	6.67	7.57		
Y_4								.0305	—.0755
Dollars per Case	Error	0.17	—0.22	0.08	0.41	—0.04	—0.85		
Iowa Farm Price	Prediction	21.59	21.67	20.44	19.04	19.73	21.30		
Y_5								.0285	.1882
Cents per Dozen	Error	0.21	—1.67	1.21	1.72	—0.89	0.55		

SUMMARY

The objective of this study is to describe the interrelationships between the shell and breaking egg markets and to provide some of the information required by a pricing committee. The specific problems dealt with are: (1) describing the structural relations which determine the allocation of egg production between shell and breaking use and which determine prices in a single month, (2) obtaining numerical values of quantity used and prices, and (3) demonstrating the ability of the models to predict prices and quantities in any particular month.

Accordingly, two five-equation models, designated as Model I and Model II, were developed. Model II differs from Model I in that it explicitly recognizes the influences of seasonal forces on the jointly determined variables. The parameters of the structural relations of both models were estimated by two-stage least squares and three-stage least squares procedures.

One adjustment made to the data was that of converting liquid egg production to breaking egg utilization by means of a variable average monthly liquid yield per case instead of a fixed liquid yield per case of 39.5 lb.

Some of the signs in the supply of breaking eggs equation of Model I did not conform with theoretical and logical expectations. For the corresponding equation of Model II, all signs were reasonable. For this reason and on the basis of overall predictive performance, the two-stage least squares version of Model II was preferred to the three-stage least squares version of Model II and to both versions (two-stage and three-stage least squares) of Model I.

The results of Model II indicated that for the period 1962-1967, the demand for shell eggs was substantially lower in the second quarter of the year than in the first but the demand for breaking eggs was considerably higher in the second quarter than in the first quarter of the year.

The monthly elasticity of demand for shell eggs at the wholesale level of marketing computed at the mean from the two-stage least squares estimates of Model II was —.49, while the monthly elasticity of demand for breaking eggs was computed from Model II two-stage least squares estimates to be —1.27.

A 1 percent increase in the New York wholesale price of shell eggs leads to an increase in the quantity of shell eggs marketed of .22 percent, while a 1 percent increase in Chicago standards and farm run breaking egg prices leads to a decrease in allocations to the shell egg market of .13 percent. A 1 percent increase in the New York wholesale price of shell eggs leads to a decrease in the number of eggs made available to breakers by 2.13 percent, but a 1 percent increase in the Chicago standards and farm run breaking egg prices results in an increase in the quantity of eggs sold to breakers by 1.06 percent (2SLS, Model II). A 1 percent increase in the New York wholesale price of shell eggs leads to an increase of .92 percent in the Iowa farm price, but a similar increase in the Chicago standards and farm run price of breaking eggs only results in an increase of .30 percent in the Iowa farm price (2SLS, Model II).

Further, the estimates of the second quarter multipliers indicated that daily shell egg utilization in the second quarter of the year was 7.7 million less than in the first quarter, but daily breaking egg utilization in the second quarter of the year was 7.4 million greater than in the first quarter. These estimates also indicated that the New York wholesale price of shell eggs was 2 cents per dozen lower in the second quarter of the year than in the first, while the Chicago standards and farm run breaking egg price also was 50 cents per case lower in the second quarter of the year than in the first quarter. Second quarter Iowa farm price was 1.6 cents per dozen lower than the first quarter, other predetermined variables held constant.

The results of the estimates of the multipliers suggested that the lower demand for shell eggs tends to encourage heavier breaking egg activity in the second quarter. Lower shell egg use in the second quarter of the year accompanied by lower shell egg prices implies that the demand for shell eggs in the second quarter is substantially lower than in the first quarter of the year. Increased breaking egg use in the second quarter of the year (the major breaking season) coincides with this period of low shell egg demand and occurs at the time when both shell and breaking egg prices are seasonally lowest.

It appears that breaking operations in the major breaking season provide an alternative market outlet for eggs which become available as a result of the lower shell egg demand and, in consequence, act as a buffer for shell egg prices. The level of breaking egg prices, therefore, appears to be linked to that of shell egg prices, while breaking egg utilization appears to be a residual claimant on egg supplies.

The Theil U value indicated that the predictions of shell egg use for the first half of 1968 tended to have smaller prediction errors than predictions of other endogenous variables in the system.

APPENDIX A. BASIC SAMPLE DATA

TABLE I.—Basic Sample Data, Endogenous Variables.

Month (t)	Average Daily Shell Egg Utilization Y_1, Millions	Average Daily Breaking Egg Utilization Y_2, Millions	Shell Egg Price, New York, Cents per Dozen	Breaking Egg Price, Chicago, Dollars per Case	Iowa Farm Price, Cents per Dozen
1961*					
January	148.4	9.5	44.18	9.98	31.93
February	146.6	14.8	46.04	10.92	34.34
March	149.9	20.1	40.93	9.82	30.91
April	148.5	22.8	36.59	9.35	27.92
May	139.3	29.0	34.86	9.15	26.80
June	133.1	28.7	37.72	9.50	27.70
July	140.1	17.3	42.79	9.17	30.82
August	139.9	13.2	46.07	8.93	32.20
September	142.2	9.9	49.73	8.69	33.88
October	145.9	10.7	46.19	8.81	34.25
November	150.5	10.1	45.60	8.54	31.28
December	154.0	9.6	42.28	8.17	29.00
1962					
January	153.9	9.7	41.80	8.47	30.25
February	152.1	12.2	39.86	8.65	28.95
March	154.8	18.1	39.68	8.51	26.64
April	153.0	22.7	36.83	8.32	26.12
May	142.6	29.6	31.22	7.82	22.95
June	135.7	31.3	32.08	7.28	21.62
July	139.0	22.7	37.12	7.13	23.19
August	141.4	15.4	43.04	7.41	28.35
September	144.0	10.5	48.66	7.91	34.89
October	148.0	8.8	43.45	8.28	32.93
November	153.5	7.5	46.59	7.88	34.00
December	155.8	6.5	43.72	7.99	31.32
1963					
January	152.5	9.0	41.31	8.18	30.30
February	150.9	12.8	41.14	9.73	31.39
March	154.7	13.2	39.15	9.64	29.40
April	151.0	13.4	33.68	8.56	24.75
May	144.2	10.6	31.08	8.18	22.52
June	141.0	9.8	33.31	8.08	23.78
July	143.8	8.6	37.45	8.18	26.43
August	144.0	7.8	40.92	8.25	27.89
September	146.4	8.5	45.92	8.79	33.33
October	149.0	8.4	41.02	9.02	31.52
November	153.9	9.2	42.88	8.77	30.50
December	155.2	9.1	41.29	8.71	28.83
1964					
January	155.1	9.7	44.36	9.19	30.82
February	154.3	13.0	37.39	8.92	26.55
March	157.1	12.8	36.78	8.78	26.84
April	150.5	13.0	30.93	8.39	23.52
May	147.0	10.7	30.60	8.12	23.03
June	142.2	10.2	33.68	7.88	23.66
July	144.5	9.0	37.16	8.09	25.98
August	148.9	8.3	43.32	8.24	30.81
September	149.2	8.9	40.88	8.49	29.57
October	151.6	8.5	39.62	8.52	28.91
November	154.3	9.2	38.62	8.38	26.79
December	157.7	9.5	36.55	7.61	24.91
1965					
January	158.3	9.6	30.74	6.93	20.42
February	154.3	13.1	31.51	7.27	21.24
March	154.7	12.6	33.55	7.43	22.33
April	157.6	13.5	36.07	7.80	23.95
May	152.8	11.6	30.26	7.68	21.20
June	145.2	11.3	33.12	7.72	22.36
July	148.1	10.0	34.57	7.93	23.69
August	149.7	9.2	40.52	7.95	27.02
September	151.0	9.8	44.35	8.39	31.00
October	154.5	9.5	42.16	8.70	32.05
November	155.9	10.4	45.62	9.42	33.50
December	157.7	10.8	46.14	9.77	34.83
1966					
January	156.3	10.6	42.64	9.66	30.55
February	155.6	14.2	46.45	10.57	34.37
March	157.6	13.9	47.29	11.59	36.00
April	155.1	14.7	42.88	10.77	32.07
May	151.8	12.8	34.57	9.01	25.21
June	145.4	12.3	36.72	8.66	25.95
July	148.6	11.0	45.32	9.30	31.60
August	150.5	10.5	46.46	10.18	34.20
September	152.8	11.3	51.44	11.58	39.24
October	158.6	10.5	45.40	11.21	35.07
November	160.6	11.1	47.96	11.69	36.62
December	162.2	11.1	45.32	11.17	33.76
1967					
January	161.7	11.2	38.02	9.30	27.76
February	158.7	15.1	35.04	7.92	23.87
March	163.3	13.8	36.08	8.11	26.02
April	161.2	14.3	29.69	7.09	20.00
May	156.9	12.4	28.70	7.06	19.70
June	151.7	12.0	27.60	6.73	19.34
July	156.7	11.3	34.81	6.74	23.25
August	155.7	10.0	32.03	7.01	21.37
September	159.3	10.4	34.98	7.20	23.90
October	162.6	10.1	28.90	6.31	20.11
November	165.4	10.5	32.39	6.36	21.20
December	169.2	10.0	34.83	6.81	23.55
1968*					
January	167.0	15.3	33.06	6.43	21.80
February	163.8	17.1	31.00	6.52	20.00
March	166.6	18.5	33.20	6.79	21.65
April	165.5	20.7	31.90	6.44	20.77
May	159.9	22.3	28.20	6.63	18.84
June	151.9	25.8	33.40	6.72	21.93

*Data for 1961 and 1968 used in calculation of the index of seasonal variation.

TABLE II.—Basic Sample Data, Predetermined Variables.

Month (t)	Wholesale Price Index, Z_1, 1957-59=100	Number of Pullets Hatched 6-21 Months Ago, Z_2, Millions	Movement into Retail Channels, Z_3, Percent Change	Lagged Egg Products Price, Z_5, Cents per Pound	Average Daily Egg Production, West North Central, Z_6, Millions	Average Daily Egg Production, Other States, Z_7, Millions	Average Hourly Wage Excluding Overtime, Z_8, Dollars per Hour	Number of Layers on Farms Over 9 Months Old, Z_9, Millions	Dummy Variables Quarters 2nd Z_{10}	3rd Z_{11}	4th Z_{12}
1961*											
January	101.0	589.0		30.75			2.16	231.47			
February	101.0	519.6		32.69			2.17	264.21			
March	101.0	509.1		30.10			2.17	272.72			
April	100.5	512.0		30.03			2.18	268.46			
May	100.0	515.3		29.85			2.18	262.30			
June	99.5	521.7		30.88			2.18	256.09			
July	99.9	539.0		30.69			2.18	246.89			
August	100.1	575.1		30.95			2.14	234.86			
September	100.0	652.0		30.60			2.15	212.60			
October	100.0	732.6		30.15			2.17	189.97			
November	100.0	779.4		29.06			2.19	180.17			
December	100.4	742.4		27.78			2.22	209.50			
1962											
January	100.8	666.3	−01.1	28.78	42.13	129.87	2.24	246.11	0	0	0
February	100.7	587.3	−00.8	28.69	43.39	134.61	2.24	271.52	0	0	0
March	100.7	565.8	−05.2	28.07	44.74	142.26	2.25	273.61	0	0	0
April	100.4	571.4	−10.6	26.82	44.37	144.63	2.25	266.49	1	0	0
May	100.2	576.1	14.4	26.60	42.94	143.06	2.25	259.63	1	0	0
June	100.0	579.8	00.1	25.54	40.27	136.73	2.24	254.44	1	0	0
July	100.4	591.2	−01.1	25.75	36.87	131.13	2.23	250.56	0	1	0
August	100.5	614.8	04.4	26.13	34.13	128.87	2.21	245.31	0	1	0
September	101.2	673.3	00.3	27.22	32.93	129.07	2.22	227.01	0	1	0
October	100.6	738.4	01.0	27.60	32.90	132.10	2.23	204.29	0	0	1
November	100.7	772.4	01.7	27.19	34.70	133.30	2.26	189.12	0	0	1
December	100.4	720.1	03.4	27.29	37.06	132.94	2.28	208.37	0	0	1
1963											
January	100.5	640.6	04.6	25.62	36.74	131.26	2.29	238.72	0	0	0
February	100.2	577.5	−00.6	29.45	37.39	135.61	2.30	263.20	0	0	0
March	99.9	564.6	02.2	28.72	39.68	144.32	2.31	268.94	0	0	0
April	99.7	567.8	−02.3	26.36	39.97	149.03	2.31	265.13	1	0	0
May	100.0	568.9	01.2	25.57	38.45	146.55	2.31	260.21	1	0	0
June	100.3	567.8	02.8	25.19	35.97	141.03	2.31	255.55	1	0	0
July	100.6	574.7	05.0	25.71	33.29	136.71	2.30	251.09	0	1	0
August	100.4	595.6	02.0	26.15	30.90	134.10	2.26	244.99	0	1	0
September	100.3	646.9	05.0	27.28	29.57	134.43	2.29	228.48	0	1	0
October	100.5	714.0	03.3	27.44	29.84	136.16	2.28	205.60	0	0	1
November	100.7	755.3	02.8	26.94	32.27	137.73	2.33	191.77	0	0	1
December	100.3	718.2	01.7	27.18	34.29	137.71	2.34	207.59	0	0	1
1964											
January	101.0	650.7	−00.5	28.64	35.71	138.29	2.37	235.10	0	0	0
February	100.5	592.4	00.2	27.38	37.62	143.38	2.36	257.66	0	0	0
March	100.4	578.5	01.5	26.53	38.16	149.84	2.37	263.16	0	0	0
April	100.3	579.5	14.0	25.19	37.73	152.27	2.38	261.36	1	0	0
May	100.1	580.8	−07.0	24.93	36.65	150.35	2.38	258.45	1	0	0
June	100.0	582.3	00.0	24.69	34.53	146.47	2.38	255.23	1	0	0
July	100.4	589.0	−02.0	25.41	32.03	140.97	2.36	251.54	0	1	0
August	100.3	609.5	01.7	25.70	29.90	139.10	2.34	245.63	0	1	0
September	100.7	662.8	−01.0	26.24	29.43	139.57	2.36	229.10	0	1	0
October	100.8	721.0	04.0	26.21	29.71	141.29	2.35	208.52	0	0	1
November	100.7	756.4	−00.5	25.58	31.63	141.37	2.38	195.81	0	0	1
Decmeber	100.8	731.6	05.0	24.24	34.03	142.97	2.40	210.05	0	0	1

TABLE II (continued).—Basic Sample Data, Predetermined Variables.

Month (t)	Wholesale Price Index, Z_1, 1957-59=100	Number of Pullets Hatched 6-21 Months Ago, Z_2, Millions	Movement into Retail Channels, Z_3, Percent Change	Lagged Egg Products Price, Z_5, Cents per Pound	Average Daily Egg Production, West North Central, Z_6, Millions	Average Daily Egg Production, Other States, Z_7, Millions	Average Hourly Wage Excluding Overtime, Z_8, Dollars per Hour	Number of Layers on Farms Over 9 Months Old, Z_9, Millions	Dummy Variables Quarters 2nd Z_{10}	3rd Z_{11}	4th Z_{12}
1965											
January	101.0	668.5	01.8	22.81	35.45	146.55	2.43	238.88	0	0	0
February	101.2	613.6	05.6	22.81	35.93	148.07	2.43	252.16	0	0	0
March	101.3	600.3	03.8	22.71	35.77	151.23	2.44	257.55	0	0	0
April	101.7	600.0	04.2	23.32	35.63	153.37	2.45	255.77	1	0	0
May	102.1	599.5	−13.0	24.23	35.23	153.77	2.46	254.06	1	0	0
June	102.8	599.6	04.0	25.85	33.90	150.10	2.45	254.01	1	0	0
July	102.9	605.7	01.8	26.47	31.80	145.20	2.42	251.24	0	1	0
August	102.9	619.6	01.0	26.36	29.71	142.29	2.40	247.52	0	1	0
September	103.0	656.1	−01.3	26.31	28.37	143.63	2.43	236.88	0	1	0
October	103.1	698.3	−00.6	27.90	28.00	145.00	2.42	222.36	0	0	1
November	103.5	724.4	02.3	29.07	29.23	145.77	2.40	210.99	0	0	1
December	104.1	697.2	02.0	30.08	31.13	145.87	2.47	218.01	0	0	1
1966											
January	104.6	640.5	−06.0	28.55	31.94	145.06	2.49	240.80	0	0	0
February	105.4	591.8	−01.8	31.29	32.54	147.46	2.49	255.99	0	0	0
March	105.4	573.9	−04.0	34.81	33.35	152.65	2.51	261.96	0	0	0
April	105.5	569.7	−02.2	33.19	33.27	155.73	2.53	261.08	1	0	0
May	105.6	569.5	−01.0	29.28	32.48	155.52	2.54	258.80	1	0	0
June	105.7	568.1	05.3	29.11	30.93	152.07	2.53	257.23	1	0	0
July	106.4	576.1	02.0	29.62	28.80	148.20	2.52	252.87	0	1	0
August	106.8	592.5	02.3	31.69	27.42	146.58	2.49	250.42	0	1	0
September	106.8	632.1	03.7	32.75	26.97	150.03	2.51	242.16	0	1	0
October	106.2	681.4	02.0	32.30	27.58	153.42	2.52	230.27	0	0	1
November	105.9	721.5	04.3	34.14	29.90	155.10	2.54	220.20	0	0	1
December	105.9	715.7	02.8	34.89	32.42	155.58	2.57	229.07	0	0	1
1967											
January	106.2	678.9	06.3	30.21	33.52	156.48	2.48	248.72	0	0	0
February	106.0	644.9	05.3	27.00	33.75	159.25	2.50	262.59	0	0	0
March	105.7	633.2	12.3	25.93	34.42	163.58	2.51	269.74	0	0	0
April	105.3	638.3	16.2	24.27	34.60	165.40	2.53	266.25	1	0	0
May	105.8	645.1	07.0	24.50	33.52	164.48	2.52	262.37	1	0	0
June	106.3	651.5	04.8	24.60	32.13	161.87	2.51	260.53	1	0	0
July	106.5	664.0	04.0	24.29	30.35	159.65	2.50	259.53	0	1	0
August	106.1	683.9	09.3	24.32	28.61	158.39	2.49	257.84	0	1	0
September	106.2	723.6	12.4	23.79	27.47	159.53	2.50	249.89	0	1	0
October	106.1	762.7	10.3	22.77	27.65	161.35	2.51	239.90	0	0	1
November	106.2	791.7	04.8	22.50	28.43	161.57	2.54	232.57	0	0	1
December	106.8	775.3	03.0	22.44	29.68	162.32	2.57	241.95	0	0	1
1968*											
January	107.2	728.0	04.0	21.86	30.50	162.70	2.62	259.58	0	0	0
February	108.0	686.3	01.75	21.50	31.00	163.60	2.64	270.97	0	0	0
March	108.2	666.0	−00.4	21.20	31.70	166.60	2.65	275.25	0	0	0
April	108.2†	661.6	−04.0	22.30	31.50	168.50	2.67†	272.29	1	0	0
May	108.3	653.9	09.5	22.20	30.30	165.40	2.68†	270.65	1	0	0
June	108.4	645.4	02.75	23.50	29.10	161.60	2.70†	269.45	1	0	0

*Data for 1961 and 1968 used in the calculation of the index of seasonal variation.
†Estimated.

Sources of Data and Computations Carried Out on Data

Y_1 Utilization of shell eggs in millions per day. Original data on egg production per month obtained from (1) Chickens and Eggs, Monthly Egg Production, Layers on Farms, Pullets Not of Laying Age, and Rate of Lay by States and Geographic Regions, Revised Estimates, 1960-64, Stat. Bull. No. 391, Stat. Reporting Serv., U. S. Dept. of Agriculture, Feb. 1967. (2) Chickens and Eggs, Layers, Potential Layers, Rate of Lay and Egg Production, Monthly, 1965-66, Pou 2-4 (3-67), Stat. Reporting Serv., U. S. Dept. of Agriculture, March 6, 1967. (3) Crop Production, CrPr 2-2, Stat. Reporting Serv., U. S. Dept. of Agriculture.

From this was subtracted eggs used for hatching, obtained from Selected Statistical Series for Poultry and Eggs through 1965, ERS 232, Econ. Res. Serv., U. S. Dept. of Agriculture; Poultry and Egg Situation, PES 248 to PES 252, Econ. Res. Serv., U. S. Dept. of Agriculture.

Also subtracted from this was the number of eggs used for breaking, including USDA purchases. Basic data were obtained from Egg Products Liquid, Frozen, Solids Production, Pou 2-5, 1-60 to 6-68, converted as explained under Y_2. These data were converted to daily numbers by dividing by number of days in month.

Y_2 Eggs broken commercially. Source of data as indicated in Y_1. Data were converted to numbers by use of a monthly yield factor obtained from a survey of yields in eight major egg products plants.

Y_3 Price of shell eggs, based on the top grade white large shell eggs reported by the U. S. Dept. of Agriculture for New York City. For most of the period, this grade was Extra Fancy Heavyweights. The average price as computed by the Dairy and Poultry Market News Service in New York was used. This price was obtained from Dairy and Poultry Market Statistics, annual issues 1960-1967, Stat. Bulls. 280, 306, 327, 342, 355, 370, 394, and 421 of the U. S. Dept. of Agriculture and monthly Cold Storage and Average Prices Reports issued by the Dairy and Poultry Market News Service, U. S. Dept. of Agriculture, New York and Newark.

Y_4 Average price paid for breaking stock delivered Chicago area, Standards and Farm Run, in dollars per case. Chicago breaker stock was used for 1960 and 1961, Dairy and Poultry Market Stat. Bulls. 280 and 306. For 1962-66, metropolitan Chicago prices and Dairy and Poultry Market Stat. Bulls. 327, 342, 355, 370, and 394 were used. For 1967, the Daily Egg Market Report issued by the Dairy and Poultry Market News Service, U. S. Dept. of Agriculture, Chicago, was used. Price was weighted average price as included in the daily report.

Y_5 Iowa farm price. The Dairy and Poultry Market News Service Report entitled Iowa Other Farm Eggs, Grade A Large or Better, Dairy and Poultry Market Statistics, Stat. Bulls. 342, 355, 370, and 394 were used. For 1967, monthly average prices were computed from the Chicago Daily Egg Market report issued by the Dairy and Poultry Market News Service, U. S. Dept. of Agriculture, price in cents per dozen. Previous to June 1962, the grade A large or better mixed color price was used from ERS Stat. Bulls. 280, 306, and 327.

Z_1 Wholesale Price Index, all commodities, 1957-59 = 100. U. S. Dept. of Labor, Monthly Labor Review, Table D-3.

Z_2 Anticipated increases in egg production. Number of pullets hatched 6 to 21 months ago were computed from egg-type chick hatch figures from Monthly Hatchery Production Report, Stat. Reporting Serv., U. S. Dept. of Agriculture.

Z_3 Movement of Eggs into Retail Channels. Percentage change for the previous month over the same month of a year earlier was computed from National Weekly Egg and Poultry Review issued by the Dairy and Poultry Market News Service, U. S. Dept. of Agriculture, New York and Newark. For 1962 to April 1963, percentage change from year ago was used in determining year ago movement; then weekly movements were totaled and monthly averages computed to determine percent change in each month from the same month a year ago. From May 1963 to date, percent change from same week year ago was used and percent change was averaged for month to get the percent change from the comparable month of a year earlier. The weekly data were put in the month in which the most days of that week appeared.

Z_4 Y_3 lagged 1 month.

Z_5 Market prices for egg products. Prices of frozen whole eggs, light colored, New York and Philadelphia, in cents per pound in 30-dozen cans in car or truck lots were used. For 1960 through 1962, weekly wholesale selling prices in New York as reported in the Dairy and Poultry Market Stat. Bulls. 280, 306, and 327 of the U. S. Dept. of Agriculture were used. Monthly averages were computed from these data by putting week in the month in which it had the most days. For 1963-66, data in the Poultry Marketing Stat. Bulls. 342, 355, 370, and 394 were used. For 1967 and 1968, Monthly Cold Storage and New York price summaries issued by the Dairy and Poultry Market News Service, U. S. Dept. of Agriculture, New York and Newark, were used.

Z_6 Egg production in the West North Central States in million eggs per day. Data were obtained from Chickens and Eggs, Revised Estimates 1960-64, Stat. Bull. 391, Stat. Reporting Serv., Crop Reporting Board, U. S. Dept. of Agriculture. For 1965-66, 1967 Chicken and Eggs Monthly report, Pou 2-4, was used. For 1967-68, data were obtained from the monthly Crop Production Report, Stat. Reporting Serv., U. S. Dept. of Agriculture.

Z_7 "Other states" production. Production in all states except Minnesota, Iowa, Missouri, North

Dakota, South Dakota, Nebraska, and Kansas. Same source as Z_6. Each was converted to daily egg production by dividing by the number of days in the month.

Z_8 Average hourly earnings excluding overtime of production workers, food and kindred products, U. S. Dept. of Labor, Monthly Labor Review, Table C-4.

Z_9 Number of layers over 9 months old in the U. S. in million head. Same basic data sources as for Z_2 and Z_6. The numbers were derived from these data by projecting the egg-type chick hatch multiplied by the following factors:

	1960-65	1966	1967-68
6th Month	.465	.460	.455
7th Month	.455	.450	.445
8th Month	.450	.440	.435
9th Month	.445	.435	.425

The numbers thus obtained were then subtracted from the total number of layers on U. S. farms as reported by the Statistical Reporting Service, U. S. Dept. of Agriculture.

Z_{10}, Z_{11}, Z_{12} Dummy variables to reflect seasonal differences.

APPENDIX B. INDICES OF SEASONAL VARIATION

TABLE III.—Moving Index of Linearly Changing Seasonal Variation in United States Egg Production, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j ($j = 1, \ldots, 6$) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
	Index ($I_{ij} = a_i + b_i t_j$)							
July	96.8225	97.0621	97.3017	97.5413	97.7809	98.0205	96.5829	.2396
August	93.4719	93.9443	94.4167	94.8891	95.3615	95.8339	92.9995	.4724
September	92.7010	93.4051	94.1092	94.8133	95.5174	96.2215	91.9969	.7041
October	94.2805	94.8515	95.4225	95.9935	96.5645	97.1355	93.7095	.5710
November	97.1034	97.3673	97.6312	97.8951	98.1590	98.4229	96.8395	.2639
December	98.8505	99.0295	99.2085	99.3875	99.5665	99.7455	98.6715	.1790
January	98.8159	99.1935	99.5711	99.9487	100.3263	100.7039	98.4383	.3776
February	102.1762	102.0749	101.9736	101.8723	101.7710	101.6697	102.2775	−.1013
March	107.5687	106.7071	105.8455	104.9839	104.1223	103.2607	108.4303	−.8616
April	108.2916	107.4969	106.7022	105.9075	105.1128	104.3181	109.0863	−.7947
May	107.4205	106.6155	105.8105	105.0055	104.2005	103.3955	108.2255	−.8050
June	102.4973	102.2523	102.0073	101.7623	101.5173	101.2723	102.7423	−.2450

TABLE IV.—Moving Index of Linearly Changing Seasonal Variation in West North Central Division Egg Production, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j ($j = 1, \ldots, 6$) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
	Index ($I_{ij} = a_i + b_i t_j$)							
July	94.0036	94.4329	94.8622	95.2915	95.7208	96.1501	93.5743	.4293
August	87.3045	88.0261	88.7477	89.4693	90.1909	90.9125	86.5829	.7216
September	84.8865	85.6307	86.3749	87.1191	87.8633	88.6075	84.1423	.7442
October	87.0412	87.4368	87.8324	88.2280	88.6236	89.0192	86.6456	.3956
November	94.7131	94.7093	94.7055	94.7017	94.6979	94.6941	94.7169	−.0038
December	102.1065	102.0587	102.0109	101.9631	101.9153	101.8675	102.1543	−.0478
January	104.0684	104.4212	104.7740	105.1268	105.4796	105.8324	103.7156	.3528
February	108.1293	107.9463	107.7633	107.5803	107.3923	107.2143	108.3123	−.1830
March	112.5936	111.7729	110.9522	110.1315	109.3108	108.4901	113.4143	−.8207
April	112.4951	111.7299	110.9647	110.1995	109.4343	108.6691	113.2603	−.7652
May	109.5065	108.8587	108.2109	107.5631	106.9153	106.2675	110.1543	−.6478
June	103.1517	102.9765	102.8013	102.6261	102.4509	102.2757	103.3269	−.1752

TABLE V.—Moving Index of Linearly Changing Seasonal Variation in Egg Production in States Other Than the West North Central Division, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j ($j = 1, \ldots, 6$) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
			Index ($I_{ij} = a_i + b_i t_j$)					
July	97.4029	97.5796	97.7563	97.9330	98.1097	98.2864	97.2262	.1767
August	95.3792	95.6108	95.8424	96.0740	96.3056	96.5372	95.1476	.2316
September	94.9112	95.4894	96.0676	96.6458	97.2240	97.8022	94.3330	.5782
October	96.2602	96.8141	97.3680	97.9219	98.4758	99.0297	95.7063	.5539
November	97.4188	97.7813	98.1438	98.5063	98.8688	99.2313	97.0563	.3625
December	97.8563	98.1090	98.3617	98.6144	98.8671	99.1198	97.6036	.2527
January	97.0549	97.5762	98.0975	98.6188	99.1401	99.6614	96.5336	.5213
February	100.4478	100.4680	100.4882	100.5084	100.5286	100.5488	100.4276	.0202
March	106.2226	105.4662	104.7098	103.9534	103.1970	102.4406	106.9790	−.7564
April	108.4002	107.4041	106.4080	105.4119	104.4158	103.4197	109.3963	−.9961
May	106.6539	105.9049	105.1559	104.4069	103.6579	102.9089	107.4029	−.7490
June	101.9920	101.7964	101.6008	101.4052	101.2096	101.0140	102.1876	−.1956

TABLE VI.—Moving Index of Linearly Changing Seasonal Variation in Breaking Eggs' Utilization, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j ($j = 1, \ldots, 6$) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
			Index ($I_{ij} = a_i + b_i t_j$)					
July	127.8254	124.5218	121.2182	117.9146	114.6110	111.3074	131.1290	− 3.3036
August	89.4649	89.4461	89.4273	89.4085	89.3897	89.3709	89.4837	− 0.0188
September	59.7663	64.7969	69.8275	74.8581	79.8887	84.9193	54.7357	5.0306
October	59.3758	62.1213	64.8668	67.6123	70.3578	73.1033	56.6303	2.7455
November	52.6239	56.9848	61.3457	65.7066	70.0675	74.4284	48.2630	4.3609
December	50.5444	54.9525	59.3606	63.7687	68.1768	72.5849	46.1363	4.4081
January	48.9211	58.9452	68.9693	78.9934	89.0175	99.0416	38.8970	10.0241
February	68.5668	78.7906	89.0144	99.2382	109.4620	119.6858	58.3430	10.2238
March	108.1730	109.8217	111.4704	113.1191	114.7678	116.4165	106.5243	1.6487
April	152.5796	145.9042	139.2288	132.5534	125.8780	119.2026	159.2550	− 6.6754
May	190.6625	175.8060	160.9495	146.0930	131.2365	116.3800	205.5190	−14.8565
June	191.4967	177.9097	164.3227	150.7357	137.1487	123.5617	205.0837	−13.5870

TABLE VII.—Moving Index of Linearly Changing Seasonal Variation in Shell Eggs' Utilization, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j (j = 1, . . . , 6) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
			Index ($I_{ij} = a_i + b_i t_j$)					
July	95.5216	95.6738	95.8260	95.9782	96.1304	96.2826	95.3694	.1522
August	95.9574	96.3434	96.7294	97.1154	97.5014	97.8874	95.5714	.3860
September	97.4126	97.6691	97.9256	98.1821	98.4386	98.6951	97.1561	.2565
October	99.4321	99.8035	100.1749	100.5463	100.9177	101.2891	99.0607	.3714
November	103.0540	102.8619	102.6698	102.4777	102.2856	102.0935	103.2461	—.1921
December	104.9078	104.5229	104.1380	103.7531	103.3682	102.9833	105.2927	—.3849
January	104.0515	103.7277	103.4039	103.0801	102.7563	102.4325	104.3753	—.3238
February	102.9421	102.4815	102.0209	101.5603	101.0997	100.6391	103.4027	—.4606
March	104.6264	104.1461	103.6658	103.1855	102.7052	102.2249	105.1067	—.4803
April	102.4226	102.1511	101.8796	101.6081	101.3366	101.0651	102.6941	—.2715
May	96.6831	97.1888	97.6945	98.2002	98.7059	99.2116	96.1774	.5057
June	92.9888	93.4302	93.8716	94.3130	94.7544	95.1958	92.5474	.4414

TABLE VIII.—Moving Index of Linearly Changing Seasonal Variation in Shell Egg Prices, New York, Extra Fancy Large, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j (j = 1, . . . , 6) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
			Index ($I_{ij} = a_i + b_i t_j$)					
July	96.2296	96.5332	96.8368	97.1404	97.4440	97.7476	95.9260	.3036
August	108.8582	108.6624	108.4666	108.2708	108.0750	107.8792	109.0540	— .1958
September	118.8215	118.0957	117.3699	116.6441	115.9183	115.1925	119.5473	— .7258
October	109.0582	108.5184	107.9786	107.4388	106.8990	106.3592	109.5980	— .5398
November	110.6039	111.0818	111.5597	112.0376	112.5155	112.9934	110.1260	.4779
December	103.5344	104.9475	106.3606	107.7737	109.1868	110.5999	102.1213	1.4131
January	105.1282	103.2324	101.3366	99.4408	97.5450	95.6492	107.0240	—1.8958
February	99.5578	98.7149	97.8720	97.0291	96.1862	95.3433	100.4007	— .8429
March	96.8987	97.5481	98.1975	98.8469	99.4963	100.1457	96.2493	.6494
April	88.7063	89.0719	89.4375	89.8031	90.1687	90.5343	88.3407	.3656
May	78.3054	79.0848	79.8642	80.6436	81.4230	82.2024	77.5260	.7794
June	84.2978	84.5089	84.7200	84.9311	85.1422	85.3533	84.0867	.2111

TABLE IX.—Moving Index of Linearly Changing Seasonal Variation in Breaking Egg Prices, Chicago Standards and Farm Run, by Months, July-June, 1961-1967, Constant Term a_i and Monthly Slope Coefficient b_i.

Month i	Year t_j ($j = 1, \ldots, 6$) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
			Index ($I_{ij} = a_i + b_i t_j$)					
July	97.1976	96.1802	95.1628	94.1454	93.1280	92.1106	98.2150	−1.0174
August	96.7324	96.8145	96.8966	96.9787	97.0608	97.1429	96.6503	.0821
September	97.0457	99.2637	101.4817	103.6997	105.9177	108.1357	94.8277	2.2180
October	100.7333	102.2076	103.6819	105.1562	106.6305	108.1048	99.2590	1.4743
November	95.1576	99.0382	102.9188	106.7994	110.6800	114.5606	91.2770	3.8806
December	93.5614	97.2391	100.9168	104.5945	108.2722	111.9499	89.8837	3.6777
January	101.1143	100.7069	100.2995	99.8921	99.4847	99.0773	101.5217	− .4074
February	111.6700	108.2563	104.8426	101.4289	98.0152	94.6015	115.0837	−3.4137
March	109.0891	107.4772	105.8653	104.2534	102.6415	101.0296	110.7010	−1.6119
April	104.5380	102.5018	100.4656	98.4294	96.3932	94.3570	106.5742	−2.0362
May	98.8458	97.0399	95.2340	93.4281	91.6222	89.8163	100.6517	−1.8059
June	94.3148	93.2746	92.2344	91.1942	90.1540	89.1138	95.3550	−1.0402

TABLE X.—Moving Index of Linearly Changing Seasonal Variation in Iowa Farm Prices, Other Production, by Months, July-June, 1961-1967, Constant Term ai and Monthly Slope Coefficient b_i.

Month i	Year t_j ($j = 1, \ldots, 6$) (1)	(2)	(3)	(4)	(5)	(6)	Constant Term a_i	Monthly Slope Coefficient b_i
			Index ($I_{ij} = a_i + b_i t_j$)					
July	91.3211	93.0935	94.8659	96.6383	98.4107	100.1831	89.5487	1.7724
August	102.5215	103.0710	103.6205	104.1700	104.7195	105.2690	101.9720	.5495
September	114.8006	115.3259	115.8512	116.3765	116.9018	117.4271	114.2753	.5253
October	114.5397	112.4047	110.2697	108.1347	105.9997	103.8647	116.6747	−2.1350
November	108.2834	108.2335	108.1836	108.1337	108.0838	108.0339	108.3333	−0.0499
December	100.5839	101.6631	102.7423	103.8215	104.9007	105.9799	99.5047	1.0792
January	112.6520	108.9287	105.2054	101.4821	97.7588	94.0355	116.3753	−3.7233
February	106.0420	104.0327	102.0234	100.0141	98.0048	95.9955	108.0513	−2.0093
March	99.6811	100.5355	101.3899	102.2443	103.0987	103.9531	98.8267	.8544
April	87.3763	89.0113	90.6463	92.2813	93.9163	95.5513	85.7413	1.6350
May	81.5797	81.9047	82.2297	82.5547	82.8797	83.2047	81.2547	.3250
June	80.6187	81.7954	82.9721	84.1488	85.3255	86.5022	79.4420	1.1767

APPENDIX C. AVERAGE DAILY EGG PRODUCTION

TABLE XI.—Average Daily Egg Production by Geographic Regions and for the United States, by Months, in Million Eggs, 1960-1967.

Month	Regions				United States
	West North Central	South	West	North East	
	Million Eggs				
1960					
January	46.42	45.26	22.35	61.19	175.2
February	46.17	47.76	23.03	60.76	177.7
March	46.19	50.26	24.13	59.94	180.5
April	47.13	52.10	24.67	60.27	184.2
May	46.74	51.32	24.58	60.23	182.9
June	43.33	47.87	24.17	57.43	172.8
July	38.77	44.87	23.52	54.74	161.9
August	35.35	43.29	23.26	52.97	154.9
September	33.33	42.97	23.40	52.17	151.9
October	33.42	42.77	23.39	52.53	152.1
November	37.10	42.47	23.33	54.90	157.8
December	41.71	42.42	23.39	56.26	163.8
1961					
January	43.77	43.87	23.90	55.84	167.4
February	45.29	48.64	24.79	56.75	175.5
March	46.84	53.58	25.48	58.61	184.5
April	46.23	54.97	25.67	58.67	185.5
May	44.23	53.84	25.65	56.94	180.6
June	41.23	50.93	25.53	54.93	172.6
July	37.32	48.45	25.23	53.19	164.2
August	34.55	47.52	24.90	52.00	159.0
September	33.53	47.97	25.00	51.63	158.1
October	34.71	48.65	25.03	52.97	161.4
November	38.17	48.83	24.43	55.73	167.2
December	41.26	48.90	24.10	57.32	171.6
1962					
January	42.13	48.55	24.58	56.97	172.2
February	43.39	52.64	25.14	56.86	178.0
March	44.74	57.90	26.06	58.03	186.7
April	44.37	59.10	27.04	58.67	189.2
May	42.94	57.55	27.42	57.68	185.6
June	40.27	54.50	26.83	55.37	177.0
July	36.87	52.06	26.32	53.00	168.3
August	34.13	50.68	26.00	51.84	162.6
September	32.93	51.03	26.53	51.63	162.1
October	32.90	52.06	26.65	53.03	164.6
November	34.70	52.47	26.23	54.83	168.2
December	37.06	51.74	26.03	55.52	170.4
1963					
January	36.74	51.68	25.23	54.77	168.4
February	37.39	54.86	25.45	54.71	172.7
March	39.68	60.65	26.97	56.35	183.6
April	39.97	63.63	27.33	57.73	188.7
May	38.45	62.03	27.55	57.06	185.1
June	35.97	59.30	27.13	54.83	177.2
July	33.29	57.06	26.55	52.84	169.7
August	30.90	55.71	26.58	51.90	165.1
September	29.57	55.73	26.80	51.50	163.6
October	29.84	57.00	26.71	52.10	165.6
November	32.27	57.83	26.67	53.57	170.3
December	34.29	57.06	26.65	53.81	171.8
1964					
January	35.71	57.74	26.23	54.10	173.8
February	37.62	61.72	26.66	54.90	180.9
March	38.16	65.68	27.84	55.90	187.6
April	37.73	67.30	28.27	56.57	189.8
May	36.65	66.45	28.45	55.77	187.3
June	34.53	63.83	28.63	54.20	181.2
July	32.03	60.90	28.16	52.10	173.2
August	29.90	59.52	28.00	51.10	168.5
September	29.43	60.06	28.10	51.30	168.9
October	29.71	61.03	27.97	52.03	170.7
November	31.63	60.90	27.53	53.04	173.1
December	34.03	61.42	27.03	54.61	177.1
1965					
January	35.45	62.61	27.48	55.45	181.5
February	35.93	64.03	28.00	55.29	183.9
March	35.77	66.19	28.16	56.06	186.7
April	35.63	68.13	28.27	56.67	189.3
May	35.23	68.81	28.26	56.03	188.9
June	33.90	66.77	28.27	54.67	184.2
July	31.80	63.94	28.06	52.90	177.3
August	29.71	62.61	27.77	51.71	172.3
September	28.37	63.04	28.17	51.37	171.5
October	28.00	64.06	28.58	51.45	172.6
November	29.23	64.67	28.37	52.37	174.8
December	31.13	64.81	27.90	52.71	177.1
1966					
January	31.94	64.58	27.94	52.65	177.1
February	32.54	65.79	28.11	52.75	179.7
March	33.35	69.26	28.81	53.68	185.6
April	33.27	72.23	29.33	52.90	189.3
May	32.48	72.06	29.19	53.52	187.8
June	30.93	70.17	29.03	52.43	183.1
July	28.80	67.81	28.74	50.77	176.7
August	27.42	67.10	28.77	50.45	174.8
September	26.97	68.80	29.30	51.27	176.9
October	27.58	70.13	29.55	52.71	180.5
November	29.90	70.90	29.27	54.20	184.8
December	32.42	71.58	28.97	54.77	188.3
1967					
January	33.52	73.00	28.94	54.84	190.3
February	33.75	74.64	29.54	54.75	193.2
March	24.42	77.00	30.58	55.10	197.6
April	34.60	78.40	30.83	55.57	200.0
May	33.52	77.23	21.23	55.03	197.6
June	32.13	75.73	31.43	53.97	193.8
July	30.35	74.71	31.23	53.00	189.9
August	28.61	74.16	31.42	52.29	187.0
September	27.47	74.97	31.83	52.23	187.1
October	27.65	75.94	31.94	52.48	188.5
November	28.43	75.87	32.10	53.33	190.0
December	29.68	75.65	31.45	54.06	191.5

Source: Chicken and Eggs, Monthly Egg Production, Layers on Farms, Pullets Not of Laying Age, and Rate of Lay by States and Geographic Regions, Revised Estimates, 1960-1964, Stat. Bull. 391, and Pou 2-4 (3-67), Stat. Reporting Service, U. S. Dept. of Agriculture.

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Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Marietta, Washington County: 20 acres

Western Branch, South Charleston, Clark County: 428 acres